RED STAR VOLUME 20

Soviet/Russian Unmanned Aerial Vehicles

Yefim Gordon

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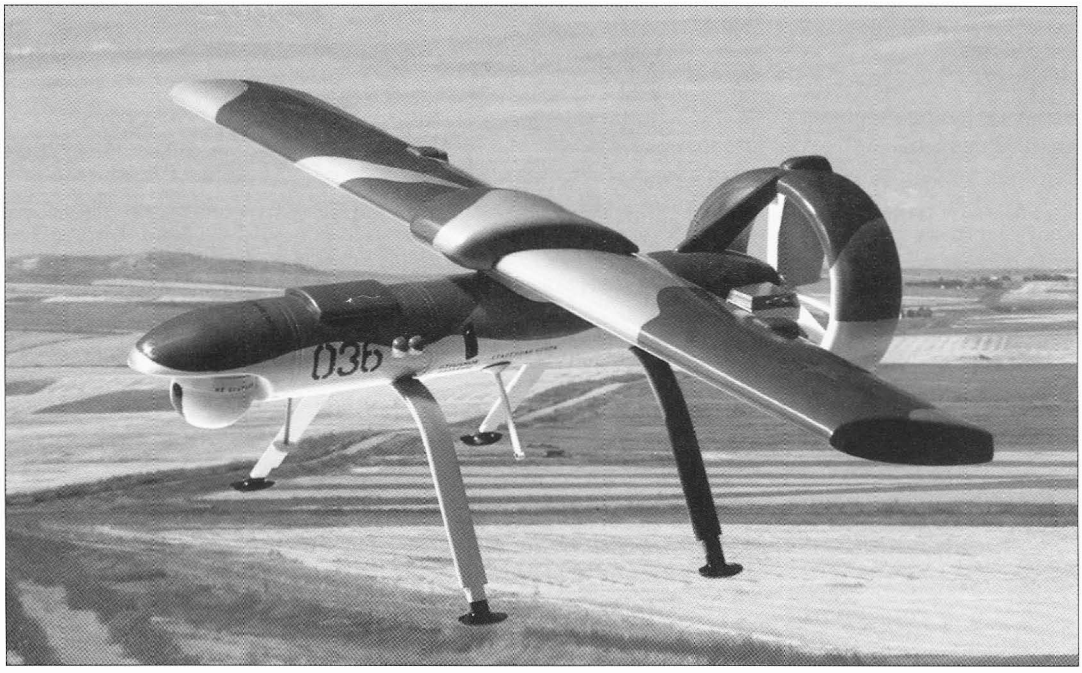

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Title page: The Yakovlev Pchela-1T is currently the Russian Army's only operational unmanned aerial system. This UAV has the distinction of having seen action in the Chechen Wars.

This page: With a ground support vehicle based on a ZiL-131 6x6 army lorry in the foreground, an early-production Tu-141 reconnaissance drone takes off on a mission in a cloud of dust.

Front cover: A Tu-143 tactical reconnaissance drone is launched from an SPU-143 self-propelled launcher.
Rear cover, top: A '123' strategic reconnaissance drone on an SARD-1 SP launcher; bottom: a late Tu-141 on an SPU-141 launcher at the MAKS-97 airshow.

Introduction

Once Nazi Germany had been vanquished, combat aircraft production at Soviet factories began winding down rapidly from May 1945 onwards as the Soviet economy moved to recover from the ravages of war and meet peacetime needs. On the other hand, the Soviet government took action to step up defence research and development efforts, including those associated with aircraft and their weapons. 1945 was the year when jet aircraft development in the Soviet Union began in earnest and at a great pace. Like any new major R&D effort, this required a lot of design talent and funding. Hence many aircraft design bureaux, including those headed by the famous designers Vladimir Mikhaïlovich Myasishchev, Pavel Osipovich Sukhoi, Viktor Fyodorovich Bolkhovitinov, Igor' Vladimirovich Chetverikov, Robert Lyudvigovich Bartini, Aleksandr Sergeyevich Moskalyov and others, were closed down in 1946-49 – ostensibly to free up resources (though, in retrospect, it is obvious that political motives and unfair play were also involved), while others were reoriented towards new tasks (notably missile system development). On the other hand, new design bureaux were set up to tackle new aspects of aircraft design; these included the now-famous companies named after their founders Oleg Konstantinovich Antonov (transport aircraft and airliner design), Mikhail Leont'yevich Mil' and Nikolay Il'yich Kamov (helicopter development).

In these conditions, when no establishment in the aircraft industry was immune against closure at the whim of the government, the competition for new programmes and state orders between three fighter design bureaux – OKB-115 led by Aleksandr Sergeyevich Yakovlev, OKB-301 led by Semyon Alekseyevich Lavochkin and OKB-155 led by Artyom Ivanovich Mikoyan and Mikhail Iosifovich Gurevich – was heightened dramatically. (OKB = ***op****ytno-kon-****strook****torskoye byu****ro*** – experimental design bureau; the number is a code allocated for security reasons.) All three OKBs had gained fame in the Great Patriotic War years when the Yak-1/Yak-7/Yak-9/Yak-3 family, the LaGG-3/La-5/La-7 family and the MiG-3 were in action against the Luftwaffe. Striving to achieve a competitive edge, the Yakovlev OKB even ventured into the field of helicopter design (but achieved scant success with the Yak-EG and the Yak-24, soon giving up rotary-wing aircraft for good).

It so happened that, while Mikoyan's propeller-driven fighters had been overshadowed and heavily outnumbered by Lavochkin's designs in the wartime years, the situation was reversed after the war when jet fighters came on the scene. Nevertheless, it was the Lavochkin OKB, not the Mikoyan OKB, that led the way in Soviet jet fighter development in the early post-war years. It was OKB-301 that pioneered the use of afterburning turbojets in the Soviet Union on the La-150F, La-156 and La-160 experimental fighters brought out in 1947, long before Mikoyan's first aircraft with an afterburner (the MiG-17F of 1951). The same La-160 was also the first Soviet swept-wing fighter which first flew on 24th June 1947, beating the Mikoyan I-310 (the future MiG-15) by a full six months. The La-176 claimed the honour of being the first Soviet aircraft to attain, and subsequently to exceed, Mach 1 in 1948-49. That said, it really makes you wonder why the La-15 (La-174D) was the Lavochkin OKB's only jet fighter to reach series production.

A reform of the Soviet Union's Air Defence Force (PVO – ***Pro****tivovoz****doosh****naya obo-****rona***) got under way in the late 1940s/early 1950s; this involved first and foremost re-equipment of the arm with the latest weapons systems. Putting the knowledge of German research in this field to good use, the Soviet defence industry began speedily developing surface-to-air missiles (SAMs), air defence radars and other components of SAM systems. The accelerated development was spurred by the ever more frequent incursions into Soviet airspace by US Air Force aircraft that maintained a close interest in Leningrad, Kiev and even flew over Moscow. This could not be tolerated of course, but PVO fighters were able to reach only a small proportion of the intruders. In 1952, for instance, there were no fewer than 34 incursions but Soviet fighters managed to destroy only three hostile aircraft, damaging another three and losing one of their own in the process (the pilot was killed). At the altitudes they habitually used, US spyplanes were safely out of reach of the then-current Soviet fighters, to say nothing of anti-aircraft artillery.

All things considered, in 1948 the Lavochkin OKB was tasked with creating several new weapons systems for the PVO. The most unusual one, and the most unexpected one as well, was the assignment to develop a family of SAMs. This was untrodden ground not only for OKB-301 but for the Soviet defence industry as a whole. Therefore the programme was monitored by none other than Lavrentiy P. Beria, Stalin's infamous Minister of the Interior in the 1940s and early 1950s who, apart from his main duties, supervised the development of new weapons.

The surface-to-air missiles developed by OKB-301 utilised the 1RD liquid-propellant rocket motor, and this type of powerplant was not wholly alien to Lavochkin. Back in 1944 the OKB had built and tested the La-7R and '120R' development aircraft; both were mixed-power fighters combining a radial engine driving a tractor propeller with a rocket booster – specifically, none other than the 1RD. The booster was installed in the rear fuselage, the rudder being suitably cropped at the base.

In parallel with the SAMs, OKB-301 commenced work on the '200' (La-200) twin-turbojet all-weather interceptor. The two-seat fighter was to be equipped with an airborne intercept (AI) radar and other avionics enabling it to intercept hostile aircraft at high altitude in fair or adverse weather.

Yet the efficiency of the PVO depended heavily not only on the new hardware but also on the training and proficiency of the men who fly the interceptors and man the SAM sites. For decades (up to the late 1940s) it was considered adequate to train anti-aircraft artillery crews and fighter pilots (flying aircraft armed with machine-guns and cannons) by giving them towed banner- or sleeve-type targets to shoot at. However, as aircraft (including those of the 'potential adversary') became faster and more technically advanced, using such targets became difficult; AI radars were being introduced on fighters, and the fabric banner- or sleeve-type targets were invisible to radars. (In an attempt to cure the problem, when the East German Air Force used Il'yushin IL-28 tactical bombers as target tugs in the 1960s for the benefit of the crews of radar-directed AA guns, aluminium cones were inserted into the 8-metre (26-ft) fabric

'sock' to provide a radar signature.) Hence a new type of towed targets resembling scaled-down aircraft in shape, size and structure made its appearance. Still, whatever the design of the target, the use of towed targets was fraught with danger – especially when SAMs came on the scene.

In the late 1940s the newly-established OKB-293 headed by Matus R. Bisnovat started work on the first Soviet air-to-air missile, the SNARS-250 (***sa****monavo****dya****shchiysya aviatsi****on****nyy reak****tiv****nyy sna****ryad*** – homing air-launched rocket projectile). Concurrently the specialists at NII-88 (*na****ooch****no-is****sled****ovatel'skiy insti****toot*** – research institute) located at Kapustin Yar began flight-testing Soviet copies of captured German surface-to-air missiles. This immediately posed a major problem. In the case of a cannon-armed fighter attacking a towed target, the horizontal separation of several hundred metres between the target tug and the target ensured adequate safety. Conversely, AAMs and SAMs could be pretty much self-minded and quite likely to lock onto the aircraft instead of the smaller target, and on occasion target tugs have been accidentally shot down.

The obvious solution was to use real aircraft (suitably fitted out with remote control or self-contained control equipment) as target drones for testing anti-aircraft weapons. They had the advantage of being similar to the would-be actual target in battle damage resistance, heat signature and radar signature, which was especially important when testing new missile systems. Originally such drones were converted from time-expired production aircraft retrofitted with radio control equipment and special autopilots; their designations were amended by the addition of an M suffix standing for *mi****shen'*** (target) – MiG-15M, MiG-17M, IL-28M, Tu-4M and so on. (Occasionally, however, the regular manufacturer prefix to the designation would be substituted by an M; thus, MiG-21PF fighters converted into target drones were designated M-21 for the sake of avoiding confusion with the MiG-21M, which was *not* a target drone.) A pilot would take the doomed aircraft into the air, climb to a predetermined altitude, put the aircraft on the required heading and eject, allowing ground controllers to take over. If the missile missed its quarry or the target survived a hit and flew on, a self-destruct command was transmitted, detonating an explosive charge to prevent the drone from dropping in the wrong place after running out of fuel.

Yet, despite its apparent simplicity, this approach required remote control systems to be developed and debugged; moreover, the remote control techniques needed to be perfected individually for each aircraft type being adapted to the target drone role. This led to the idea of creating a standardised target drone for the Soviet Air Force – a dedicated low-cost aircraft of simplified design that would be easy to manufacture in large numbers. Again, OKB-301 was one of the first to be put on this job.

Thus, the early 1950s saw the development of the first Soviet unmanned aerial vehicles (UAVs) designed with series production in mind. At first these were mostly target drones, but reconnaissance UAVs followed soon enough.

UAV development received additional impetus after the Vietnam War, based on the US Air Force's successful use of Ryan BQM-34 Firebee reconnaissance drones in Vietnam. In more than one country, studies got under way on ultra-light remotely piloted vehicles (RPVs) with a take-off weight of 50-200 kg (110-4,410 lb) designed for tactical reconnaissance duties. The USA led the way, and the example was soon followed by Israel which quickly developed and fielded several models of ultra-light RPVs; these proved their worth during the constant clashes with the surrounding Arab nations.

Inspired by the Israelis' massive and successful use of mini-RPVs in Lebanon during the fighting in the summer of 1982, the Soviet military leaders began to show a heightened interest in this class of aircraft. An experiment held in the USSR in the early 1980s demonstrated the value of such aerial vehicles over the battlefield. A battalion of ZSU-23-4 Shilka 23-mm (.90 calibre) self-propelled AA guns fired on a miniature radio-controlled target drone simulating a reconnaissance mini-RPV. The Shilka had a well-earned reputation as one of the best AA guns in its day and was very deadly against low-flying manned aircraft; still, the gunnery results astounded everyone – in spite of the sophistication of the radar-directed quadruple guns and the skill of their crews, the drone got away unscathed.

In addition to conventional (aircraft-type) UAVs, this book describes the rotary-wing RPVs and the mini-RPVs created in the Soviet Union and subsequently Russia. The unmanned aerial vehicles developed by Russian companies in recent years may well find civil uses (such as ecological monitoring and law enforcement) in addition to military ones.

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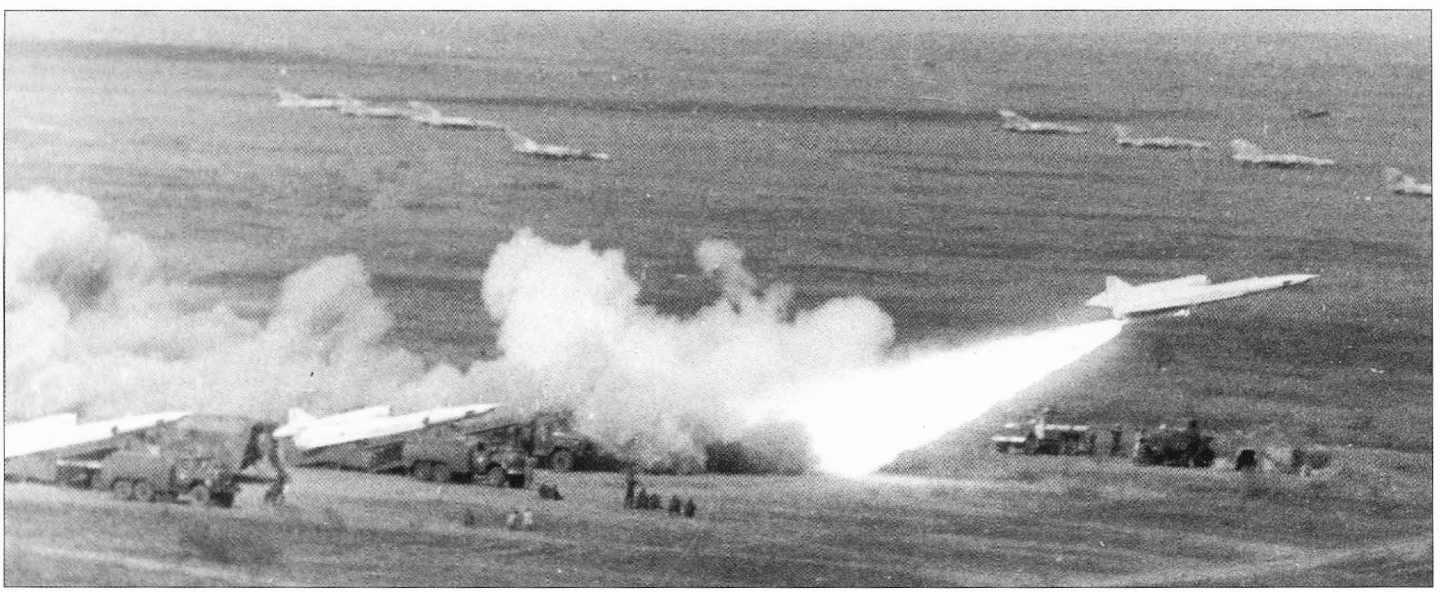
The author wishes to thank Vladimir Rigmant for supplying valuable photos and information on the Tupolev OKB's UAVs; Dmitriy Komissarov for doing the translation job and making important additions to the text; and Nigel Eastaway of the Russian Aviation Research Trust for supplying additional material.



A squadron of Tu-141 reconnaissance drones is seen during an exercise. One drone takes off, while two others wait their turn; UPG-300 ground power units based on the ZiL-131 are parked beside each launcher. Read about the Tu-141 and other Tupolev designs in Chapter 2.

Chapter 1

Lavochkin's Smallest

and Biggest

La-17 target drone (*izdeliye* 201)

As recounted in the introductory section, the need for an all-purpose target drone suitable for training the PVO's SAM crews and Soviet fighter pilots alike arose in the early 1950s. Since there were no specialised design bureaux tasked with developing such hardware at the time, Soviet Air Force Commander-in-Chief Air Marshal K. A. Vershinin approached the well-known aircraft designer Semyon A. Lavochkin with a request to design the drone.

On 10th June 1950 the Soviet Council of Ministers issued a directive tasking experimental plant No.301 in Khimki (a northern suburb of Moscow), which was home to Lavochkin's design team, with creating a standardised target drone. The apparatus was to have comparable flight performance to the jet aircraft of the day, be of simple design and cheap to manufacture. (It should be noted that the enterprise was still called 'experimental plant No.301' at the time; the appellation 'OKB-301' came into being a while later.)

Thus, contrary to popular belief, development of the target drone (known in-house as *izdeliye* 201) began ahead of the S-25 Berkoot (Golden Eagle) SAM system. (*Izdeliye* (product or article) such and such was, and still is, a common way of designating Soviet/Russian military hardware items.) The two programmes were not directly related; on the contrary, due to the much higher priority of the SAM programmes the OKB's resources were taxed to such an extent that development of the target drone suffered serious delays and the completion deadline was repeatedly shifted by appropriate government directives.

The *izdeliye* 201 programme was initially supervised by I. A. Merkoolov, an engineer known for his ramjet boosters which found use on several experimental fighters designed by Nikolay N. Polikarpov. Later A. G. Chesnokov succeeded him in this capacity.

The cost factor had a decisive influence on the drone's design features. The drone was somewhat similar in design to the German V-1 (Fieseler Fi 103) 'buzz bomb', except that the engine was a ramjet, not a pulse-jet, and was underslung instead of being mounted above the rear fuselage atop the vertical tail; the tail unit had a cruciform design. The designers had kept the contours and aerodynamics as simple as possible. The wings and tail surfaces all used the same TsAGI SR-11-12 airfoil and had a rectangular planform with slightly rounded tips.

Weight efficiency had been sacrificed to ease of manufacturing. For instance, the fuel tank occupying most of the fuselage length and absorbing the structural loads from the wings and tail unit was a welded steel structure. At that time it was easier to manufacture a hermetically sealed welded steel tank than a similar structure made of aluminium alloy.

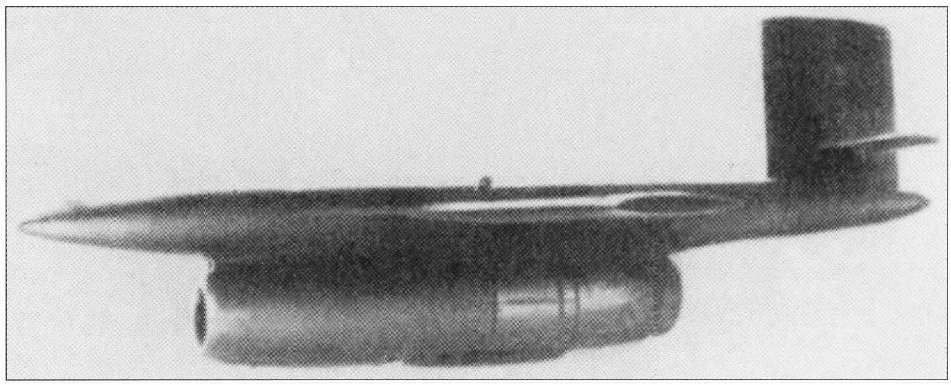
The choice of a ramjet engine for the Lavochkin drone was again dictated by its simplicity and low cost. The design staff of plant No.301 already had some experience with ramjets; the La-126PVRD (alias '164') and La-138 experimental fighters, both equipped with PVRD-430 boosters (*pryamo**toch**nyy vozdoosh**no**-reak**tiv**nyy **dvig**atel'* – ramjet engine) under the wings, had been developed and tested in 1946-47. It is well known that the ramjet engine has no revolving parts; its principal components are the air intake and the combustion chamber. The air intake section is specially profiled to increase the pressure of the air supplied to the combustion chamber into which the fuel is fed and ignited. The combustion products with a temperature in excess of 1,000°K are ejected at great speed, creating thrust.

OKB-670 led by Mikhail M. Bondaryuk (the one which had developed the above-mentioned PVRD-430) had by then almost completed development of a rocket motor for an anti-shipping cruise missile designed for the Shtorm (Sea Storm) coastal defence weapons system. It was thus in a position to take on development of a similarly rated engine designated RD-800 for the *izdeliye* 201 drone. In keeping with the OKB's traditions the digits in the designation were derived from the engine's casing diameter (800 mm; 2 ft 7½ in). In order to cut costs the designers dispensed with a fuel pump; the fuel was forced out of the tank and fed to the engine by compressed air stored in spherical bottles.

The drone's AP-53 autopilot was a product of OKB-112 headed by Chief Designer B. Ye. Antipov, the Ministry of Aircraft Industry's leading specialist organisation responsible for this type of hardware. The autopilot used pneumatic servos fed from the same compressed air bottles as the fuel tank pressurisation system. The task of reconciling design simplicity with satisfactory performance was not easily accomplished and the designers had to make three tries before the result was acceptable. The original AP-53 was replaced in 1952 by the more advanced AP-60, which in turn gave way to the AP-61 a year later.

In addition to the autopilot, the drone featured a radio control system developed by N. I. Belov's design team at NII-648, which in those days was one of the top-ranking research establishments concerned with control systems for guided missiles and other unmanned aerial vehicles. The system's wire aerials ran from the centre fuselage to the tips of the horizontal tail. Electric power was provided by a generator driven by a two-bladed propeller-like vane in the extreme nose.

From an early stage of the *izdeliye* 201's development the designers considered



The original ramjet-powered air-launched version of the La-17 (note the dorsal attachment lug amidships).

reusing the drone if it was lucky enough to escape destruction on the first try. Therefore the original intention was to equip the drone with a parachute/retro-rocket recovery system and special inflatable bumpers to cushion the impact on touchdown. However, these devices were found to be too complicated; they imposed a weight penalty and occupied a lot of internal space, with an according reduction in fuel capacity. Besides, such a landing was regarded as an abnormal (in the sense of poor marksmanship, that is!) and infrequent occurrence. Hence the vertical recovery arrangement was abandoned in favour of a horizontal landing, the engine nacelle serving as a landing skid. Unlike the turbojet engine, the ramjet was 'hollow' (that is, lacking a compressor/turbine/shaft assembly) and could serve as a crushable bumper absorbing the impact.

From a design and operational concept standpoint the *izdeliye* 201 had only one inherent flaw, namely the ramjet engine. By definition a ramjet requires a certain amount of slipstream pressure (that is, forward speed) to operate, rendering autonomous take-off impossible; this meant the drone had to be taken aloft by a drone launcher aircraft. Initially the Soviet Air Force contemplated the World War Two vintage Tupolev Tu-2 tactical bomber, which was obviously obsolete but still available in large numbers, for this role. However, the Tu-2 had a tailwheel undercarriage, and the drone's bulky ventral engine nacelle and tall vertical tail made ventral carriage impossible; mounting the drone above the Tu-2's fuselage on struts was dismissed as too dangerous.

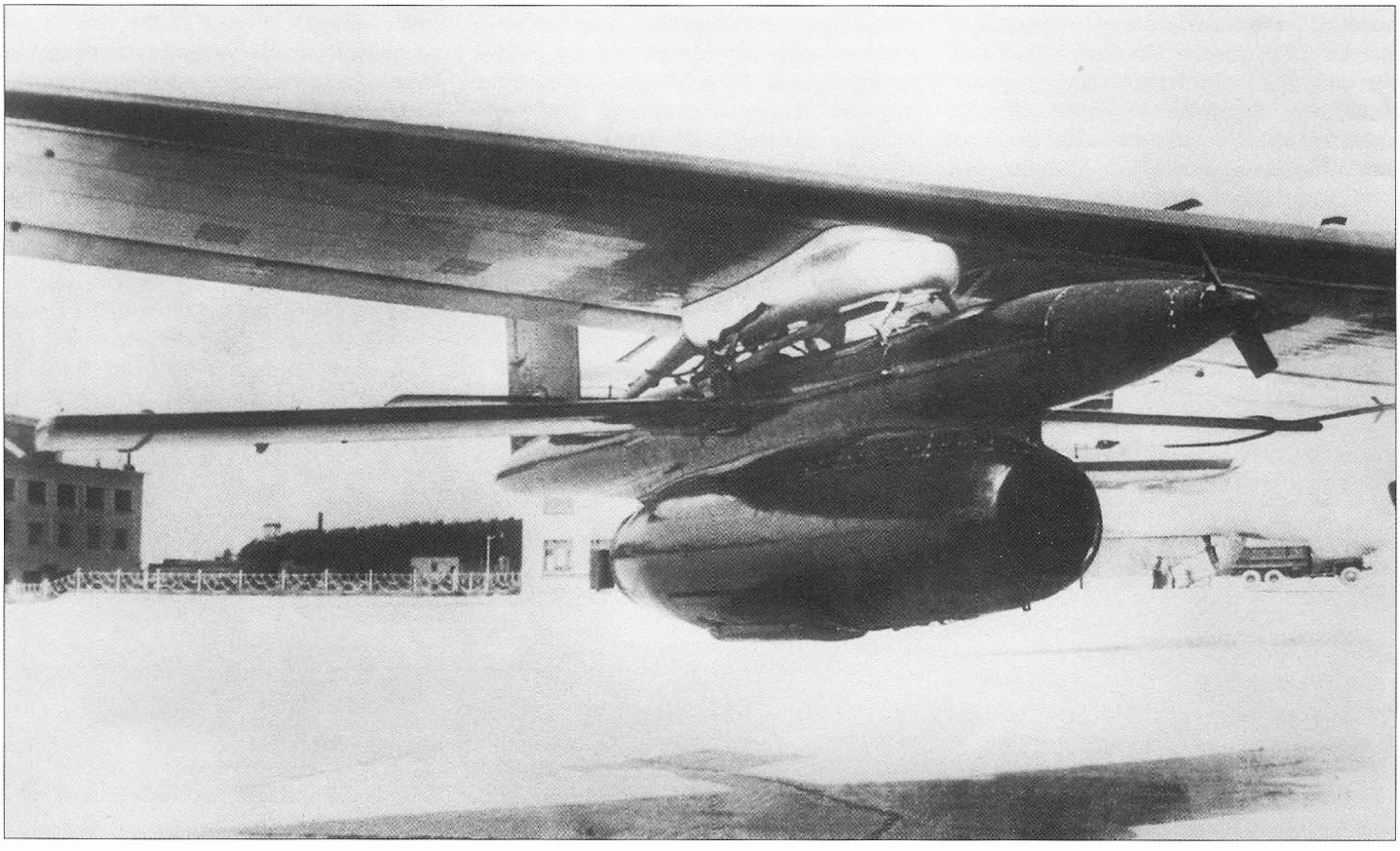
Ground tests and refinement of the first prototype *izdeliye* 201 began in 1951; this stage included flutter and vibration testing of the airframe on a special rig and integration of the drone's systems. The first flight date, however, kept slipping because the 'subcontractors' responsible for some of the components were late in delivering them. Thus, the parachute/rocket recovery system and autopilot were still far from perfect; development of the RD-800 ramjet was also running behind schedule.

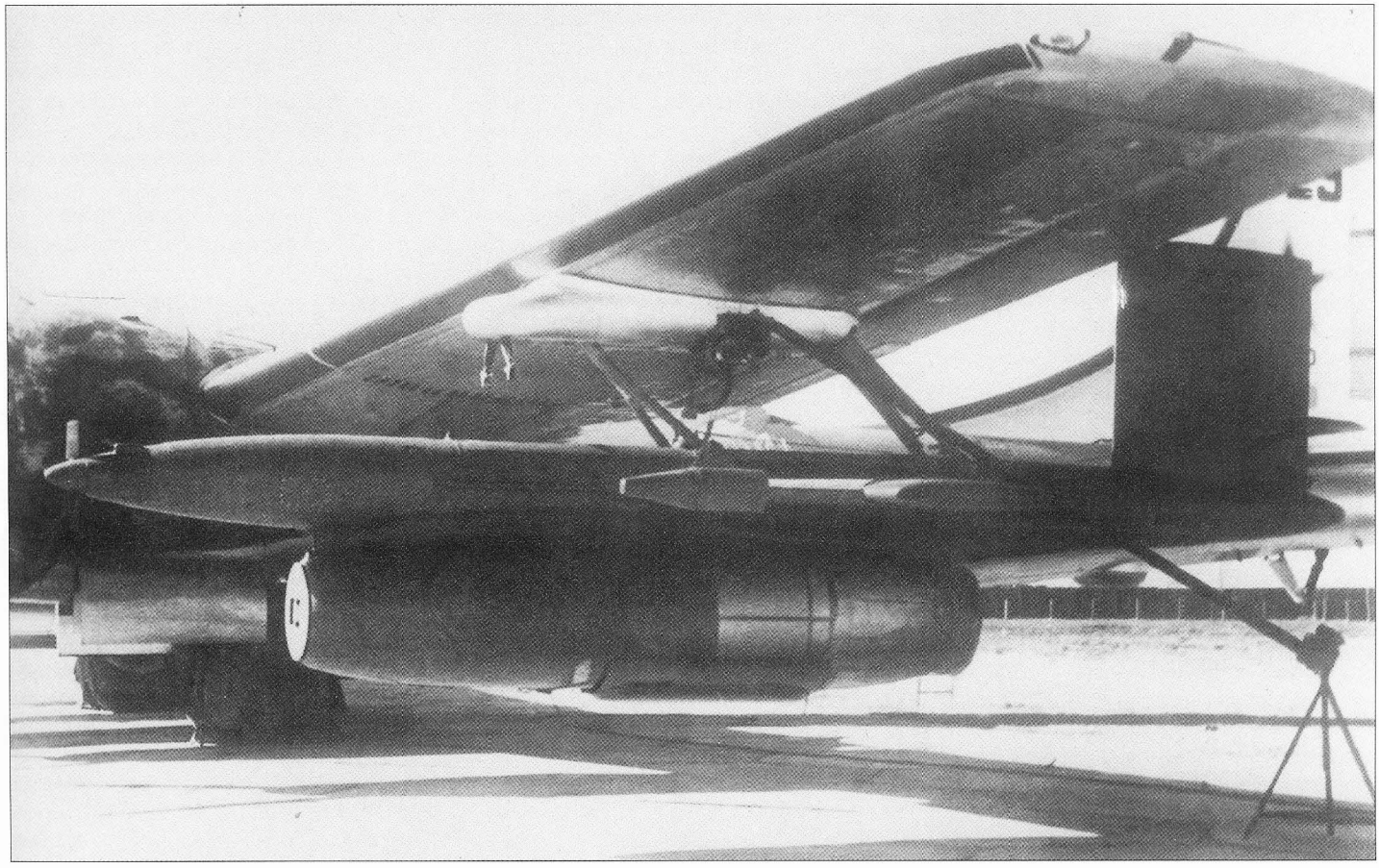
Since the Tu-2 proved unsuitable as a launch platform, towards the end of the year OKB-301 accepted an idea floated by the Flight Research Institute named after Mikhail M. Gromov (LII – ***Lyot****no-is****sled****ovatel'skiy insti****toot***) that envisaged adapting the Tu-4 heavy bomber for the drone launcher role. Two drones were to be carried on underwing pylons outboard of the Nos 1 and 4 engines. In 1952 this configuration was chosen as the principal one. In April of that year the Council of Ministers ordered the flight tests of the *izdeliye* 201 to be postponed until the second quarter of 1953.

In the course of development the drone was redesigned to take a bigger (both literally and figuratively) engine. The new ramjet had a casing diameter of 900 mm (2 ft 11⅞ in) and was accordingly designated RD-900. The engine's dry weight was 320 kg (705 lb); at a flight speed of 865 km/h (537 mph) the RD-900 delivered a thrust of 625 kgp (1,380 lbst) at 5,000 m (16,400 ft) and 425 kgp (940 lbst) at 8,000 m (26,250 ft).

A late-production Kazan'-built Tu-4 bomber serialled '29' (c/n 2205710) was converted into a 'mother ship' for conducting the manufacturer's flight tests of the *izdeliye* 201 drone by removing all offensive and defensive armament and installing two pylons under the outer wings. The tests were held by plant No.301 jointly with the Soviet Air Force State Research Institute named after Valeriy P. Chkalov (GK NII VVS – *Gosoo****dar****stvennyy krasnozna****myon****nyy na****ooch****no-is****sled****ovatel'skiy insti****toot*** *Vo****yen****no-voz****doosh****nykh seel*). The institute's main seat was then at Chkalovskaya airbase about 30 km (18.5 miles) east of Moscow; however, holding the tests in the Moscow Region was impossible for safety reasons, so the tests took place at Vladimirovka AB in Akhtoobinsk near Saratov, southern Russia. An MRV-2M remote control system comprising two ground transmitters was deployed at the test range; the drones' flight was monitored by means of a P-30 radar – one of the first Soviet air defence/air traffic control radars with a 360° field of view – or an SON-4RR artillery spotting radar.

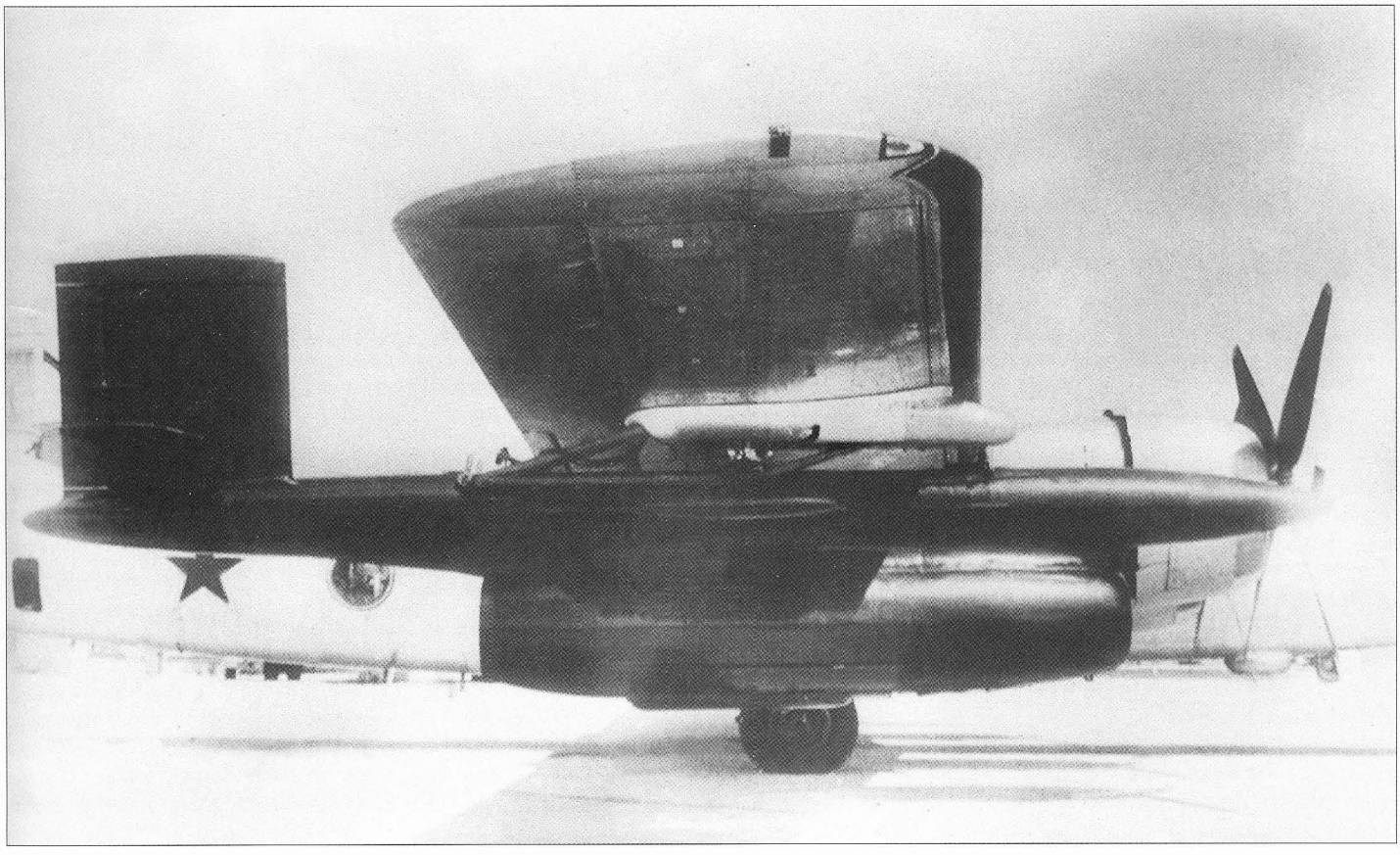
Manufacturer's flight tests of the *izdeliye* 201 drone commenced on 13th May 1953; no ground control was used initially, the drone's

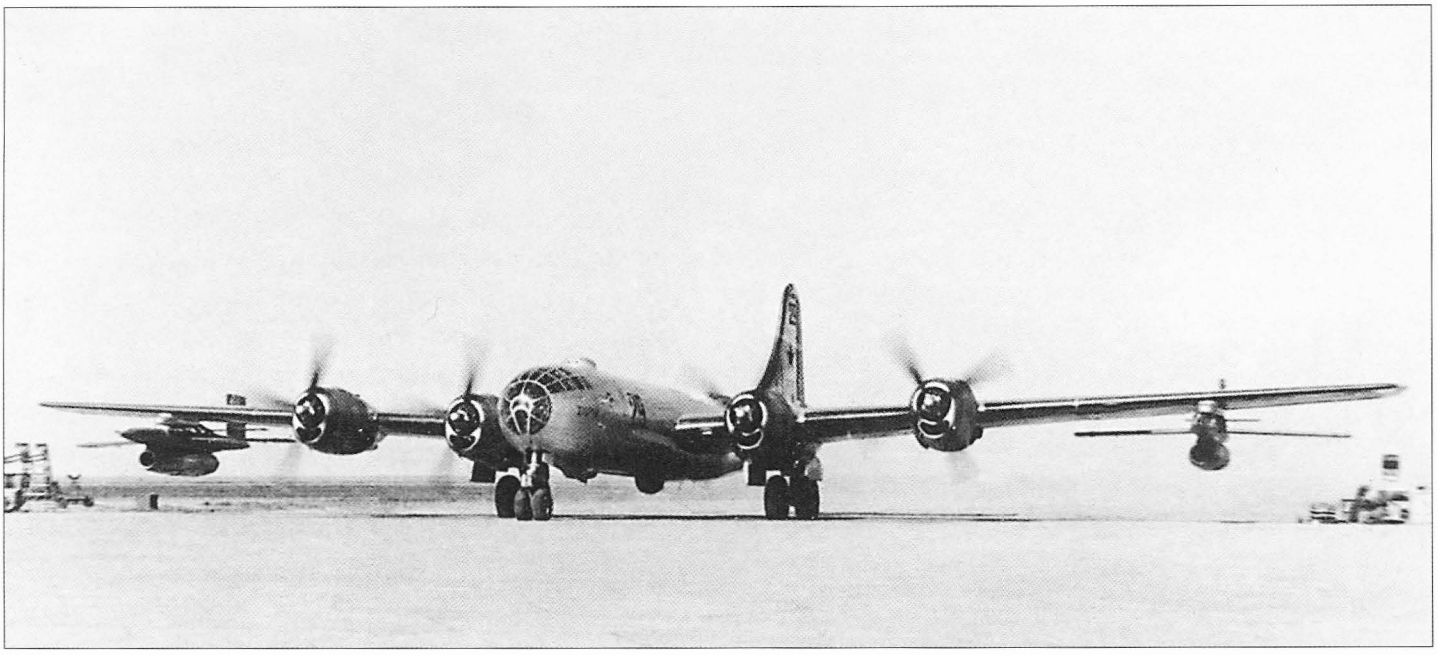




Above: A La-17 is hooked up to the port pylon of the first Tu-4 modified for the drone launcher role. The pylon design is well visible, featuring two pairs of trailing arms (similar to the bomb cradles of some dive bombers) and sway braces at the front. Note the hand-driven hoist on a tripod and the cover on the wing pitot.

Below and opposite page: A La-17 *sans suffixe* on the starboard pylon. The large ramjet and large tail make a striking contrast with the slender fuselage.





Top and above: The first Tu-4 converted as a 'mother ship' for two La-17 target drones ('29', c/n 2205710) seen during the La-17's trials. The machine-gun barbettes are still there but all armament has been removed. The top photo shows clearly how far outboard the pylons are positioned; note also the drones' wing anhedral.

autopilot being programmed to follow a certain course. Early test flights revealed inadequate engine thrust at low speeds – by jet standards, that is. When the drones were released by the Tu-4 at 8,000-8,500 m (26,250-27,890 ft) and about 500 km/h (310 mph) – which was no mean achievement for the heavy bomber! – the RD-900 could not generate enough thrust to stop the drone from decelerating, never mind acceleration. As a result, upon separation the drone entered a dive and took about 90 seconds to recover from it. Having worked up a speed of 845-905 km/h (525-562 mph), the drone was capable of making vigorous manoeuvres and even climbing; on one occasion it clawed its way up to nearly 10,000 m (32,810 ft).

The manufacturer's flight tests showed that *izdeliye* 201 needed refinement. Hence in June 1953 the Council of Ministers ordered the tests to be suspended until further notice.

State acceptance trials of the *izdeliye* 201 took place at GK NII VVS between 13th June 1954 (Lavochkin seemed to make a point of defying superstition) and October (some sources say September) 1954; the effort involved 10 drones and 12 engines for them. The RD-900's designated service life was set at 40 minutes, the maximum continuous operation time in flight being between 720 and 1,245 seconds. Three drones were fired upon by 100-mm AA guns which claimed one of the drones; another three were launched as targets for MiG-17 fighter pilots, and one drone made three flights specifically for verifying the possibility of recovering it in the event it was not shot down.

The Tu-4 drone launcher aircraft made 19 flights in the course of the state acceptance trials; 13 of them involved drone launches, including one occasion when both drones were released simultaneously. In each case the drone was escorted by a MiG-15 fighter which, after receiving appropriate orders, could destroy the drone if it strayed from the

intended course. The tests confirmed that the drone could maintain a constant preset speed anywhere between 575 and 905 km/h (357-562 mph); the flight took place at altitudes between 2,800 and 9,750 m (9,190-31,990 ft). Maximum engine operation time was 8.5 minutes. The drone had a launch weight of 1,506 kg (3,320 lb), including 415 kg (915 lb) of aviation gasoline (Avgas) and 46 kg (101 lb) of compressed air; the structural weight did not exceed 1,063 kg (2,343 lb). The basic performance figures established at this stage were a top speed of 253 m/sec (910.8 km/h, or 565.7 mph), a maximum autonomous flight altitude (with manoeuvres) of 9,750 m and a powered flight time of 664 seconds; the ramjet ignited reliably between 4,300 and 9,300 m (14,110-30,510 ft). The other performance parameters met the operational requirement.

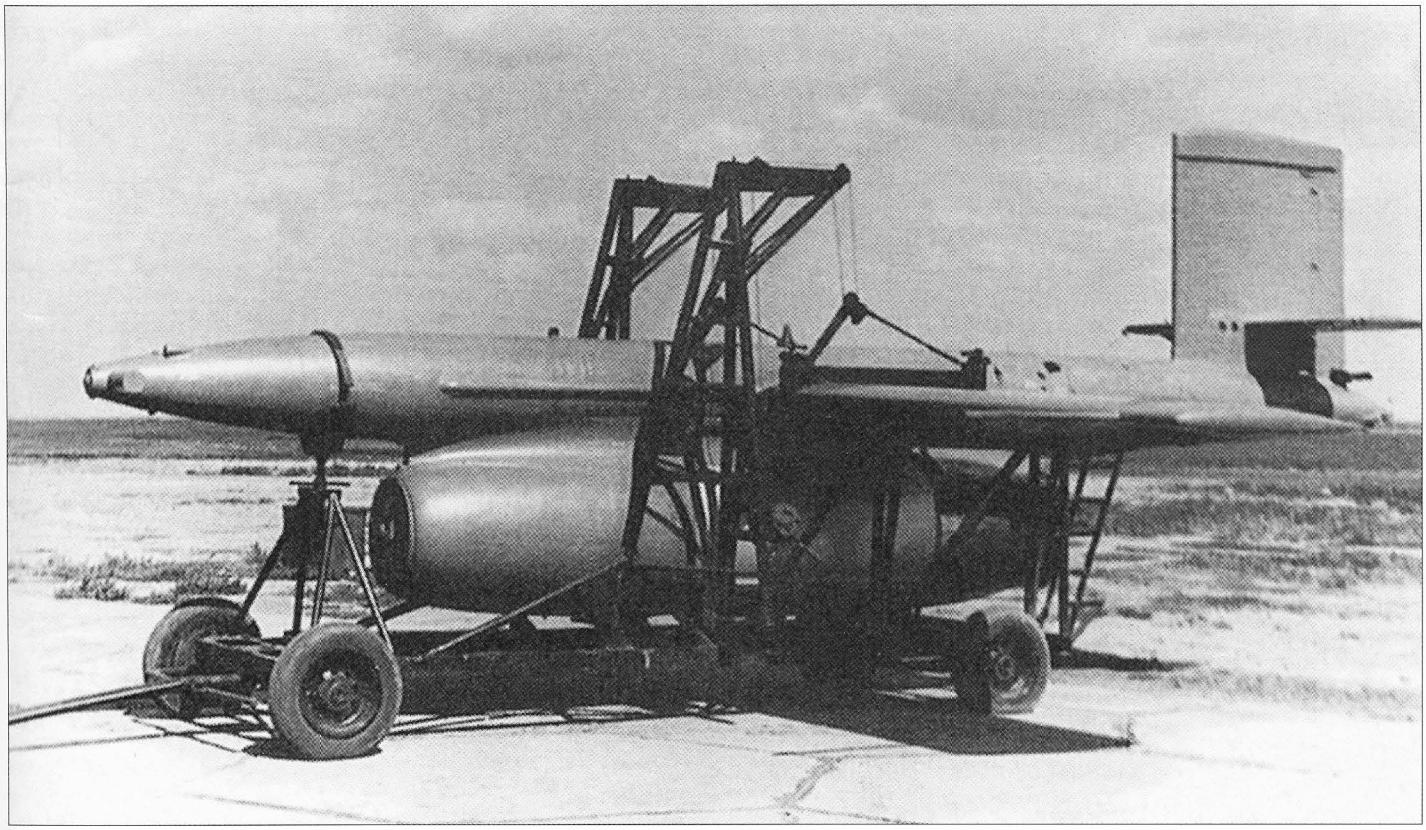
The drone's flight profile was as follows. Immediately after release the UAV entered a shallow dive, levelling out five seconds later and accelerating to maximum speed 80-100 seconds after launch. During this time it lost between 900 and 1,600 m (2,950-5,250 ft) of altitude. At this stage of the flight the drone was stabilised by the autopilot and tracked by a ground radar tuned to the signal of the onboard SO-12A transponder (*samo**lyot**nyy ot**vet**chik* – 'aircraft-mounted responder'). Then the drone control operator guided the drone to the designated intercept area; if it was lucky enough to survive the attack unscathed, it glided after running out of fuel as the operator directed it to the landing zone. After descending to about 500 m (1,640 ft) the drone automatically assumed a nose-high attitude for landing and touched down with a sink rate of 5.5-5.8 m/sec (1,082-1,141 ft/min); the landing run – or should we say scrape? – amounted to 40-100 m (1,310-3,280 ft). In so doing the engine suffered fatal damage, but it had by then reached the limit of its service life and would have to be replaced anyway before the drone was re-used; also, engine replacement was fairly straightforward.

In the course of the state acceptance trials it was discovered that the endurance could be increased by 1.5 minutes by throttling back the engine to save fuel; this required modifications to the radio control system allowing the appropriate command to be transmitted. When the engine quit due to fuel starvation, the drone continued climbing (or rather coasting) for another 80-100 seconds, losing speed rapidly; then it began a descent with a sink rate of 8-10 m/sec (1,574-1,968 ft/min), travelling at 300-340 km/h (186-211 mph). The transition to pre-landing AOAs was now triggered by a radio command, reducing the sink rate by half.

The trials revealed the drone's small radar cross-section (RCS); the RP-1 *Izum**rood-1* (Emerald-1) and Izumrood-2 centimetre-waveband radars fitted to some of the first Soviet all-weather fighters could detect the *izdeliye* 201 at a range of not more than 2-3 km (1.24-1.86 miles), achieving a target lock-on at 1.1-2.5 km (0.68-1.5 miles). (RP = ***rah**diopri**tsel*** – 'radio sight', the Soviet term for fire control radars.) This hampered the tests of the K-5 beam-riding air-to-air missile which were under way at the time, as the missile's minimum launch range exceeded 3 km.

Given the positive results of the state acceptance trials, the *izdeliye* 201 drone was cleared for production and Soviet Air Force service, receiving the service designation La-17. The conclusion of the state commission's report on the trials results recommended holding service tests of the *izdeliye* 201 in 1955; to this end five further Tu-4 bombers were to be converted into drone launcher aircraft. And so they were; together with the example involved in the state acceptance trials the number of Tu-4s thus modified at aircraft factory No.22 in Kazan' (one of three which built the type) rose to six but no more conversions followed.

As early as 1952, plant No.47 in Orenburg – later renamed the *Stre**la*** (Arrow) Production Association – began tooling up to produce izdeliye 201. This practice of gearing up for production well in advance of the official go-ahead or even the completion of the trials was quite common in the Soviet Union. In 1956 full-scale production of the La-17 was launched at aircraft factory No.21 in Gor'kiy – now the ***Sok**ol* (Falcon) Nizhniy Novgorod Aircraft Factory – which built nearly 250 drones before production of the original air-launched model ended.



A La-17 *sans suffixe* on a ground handling dolly equipped with hoisting and retaining devices. La-17s were devoid of markings, except for maintenance stencils.

Above: 'Sing a song of targets, an engine full of snow...' Due to the La-17's landing technique it scooped up an engineful of dirt or snow before coming to a stand-still; however, the short-life ramjet was by then a write-off anyway.

A La-17 (or, more probably, a La-17M) is on display at the North Fleet Air Arm Museum in Safonovo near Severomorsk.

The La-17 in detail

Type: Reusable subsonic target drone. The all-metal airframe structure is made of riveted duralumin and welded steel.

Fuselage: Circular-section structure built in five pieces, with a maximum diameter of 0.55 m (1 ft 9 21/32 in). The *forward fuselage* has a parabolic shape; it accommodates avionics and electric equipment, including the DC generator in the extreme nose driven by a two-bladed propeller-like vane.

The cylindrical *centre fuselage* is a one-piece monocoque welded steel structure which is the fuel tank; it features wing and engine attachment fittings and incorporates spherical compressed air bottles for fuel tank pressurisation and autopilot servo operation. The tapered *rear fuselage* carries the tail surfaces and houses more avionics and equipment.

Another survivor in a summer setting, awaiting recovery.

Wings: Cantilever mid-wing monoplane with unswept wings of basically rectangular planform; span 7.5 m (24 ft 7 3/32 in), area 8.55 m² (91.93 sq ft), chord 1.14 m (3 ft 8 7/8 in), anhedral 2°. The wings are of single-spar stressed-skin construction utilising a TsAGI SR-11-12 airfoil with a constant thickness/chord ratio; they are one-piece structures and are easily detachable for transportation. The wings have one-piece ailerons but no high-lift devices. The port wing carries a pitot boom with pitch/yaw vanes and a tracer on the trailing edge permitting visual tracking of the drone from the ground at night.

Production La-17s have teardrop-shaped wingtip fairings housing compressed air bottles which were absent on the prototypes. They serve to increase the air supply and enable normal operation of the fuel system at higher altitudes, thereby increasing the drone's service ceiling.

Tail unit: Cruciform unswept cantilever tail surfaces of rectangular planform with slightly rounded tips; horizontal tail span 2.18 m (7 ft 1 53/64 in). The tail surfaces have the same TsAGI SR-11-12 airfoil and feature a one-piece rudder and one-piece elevators.

Powerplant: One closely-cowled Bondaryuk RD-900 ramjet under the centre fuselage. The RD-900 has a maximum rating of 800 kgp (1,760 lbst) at Mach 0.76 and 5,000 m (16,400 ft); bench tests had shown a thrust of 290 kgp (640 lbst) at Mach 0.42 and 390 kgp

(860 lbst) at Mach 0.5. Dry weight 305 kg (672 lb); length overall 4,085 mm (13 ft 4 53/64 in), maximum diameter 900 mm (2 ft 11 7/16 in).

Control system: Mechanical controls with an AP-61 autopilot featuring pneumatically actuated servos. A radio control system is provided.

Fuel system: The RD-900 runs on 70-octane B-70 grade Avgas carried in the centre fuselage integral tank. Fuel is fed to the engine by air pressure (the tank is pressurised); a fuel flow regulator adjusts the fuel feed, depending on the speed and altitude.

Avionics and equipment: SO-12A transponder for determining the drone's position by means of ground radars.

La-17M target drone (*izdeliye* 203)

While used with considerable success for training fighter pilots and SAM crews, as well as for testing new models of air-to-air and surface-to-air missiles, the baseline La-17 *sans suffixe* (*izdeliye* 201) suffered from several major weaknesses. One of them was the need to use Tu-4 drone launcher aircraft. For one thing, the piston-engined Tu-4 took two hours to reach the required launch altitude, during which time the situation could change to such an extent that the live weapons practice session or test mission would have to be called off. Another thing was that the Tu-4 was a gas-guzzler; thirdly, the limited number of serviceable drone launcher aircraft made it impossible to simulate massive air raids by launching large numbers of drones and restricted the areas where live weapons training could take place.

All of this led the Soviet military to propose launching the drone from a mobile ground launcher; the latter could be modified from a wheeled AA gun mount and transported together with the drone. Such an installation allowed the drone to be launched in any required direction and at various elevation angles.

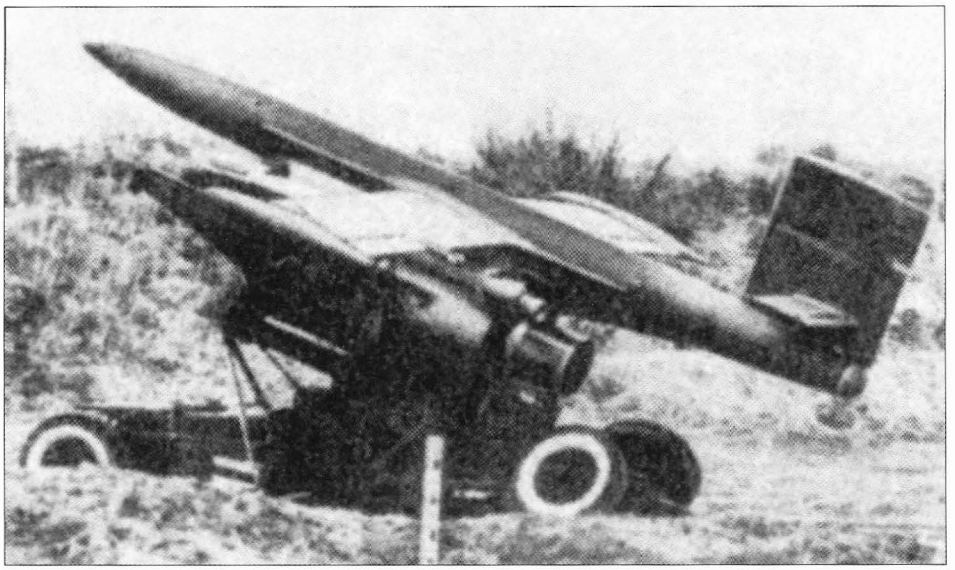
Another major shortcoming of the La-17 *sans suffixe* was associated with the drone itself. Even at the design stage the designers at OKB-301 were aware that a ramjet was not the best option for a target drone. The RD-900 was way too thirsty, using up the 700 litres (154 Imp gal) of fuel within a very short time, which left a fighter pilot no time for a second attack if he missed the target on the first try. Finally, there was the need to be able to use the drone in adverse weather and away from airfields (during combined-arms exercises and at remote weapons test ranges).

Having made a thorough study of the operational experience accumulated with the La-17, the drone's project chief A. G. Chesnokov came up with the project of a target drone that would meet all the requirements associated with live weapons training. As a 'private venture', OKB-301 started work on a new drone known in-house as *izdeliye* 203 – a thoroughly reworked ground-launched version of the La-17. The mobile launcher was based on the four-wheel mount of the KS-19 100-mm (3.93-in) AA gun. The RD-900 ramjet was to be replaced by the mass-produced Mikulin RD-9B axial-flow turbojet borrowed from the MiG-19 fighter.

However, Chief Designer Semyon A. Lavochkin was opposed to the idea, as OKB-301 had more than enough work to do as it was. The 'subcontractors', who had mastered production of the RD-900 ramjet, were also unhappy about the prospect of losing this order, and the proposal was shelved for the time being. Still, Chesnokov did not give up so easily; he managed to win the support of the then PVO Commander, Air Marshal K. A. Vershinin, who phoned Lavochkin and told him the idea was sensible and should be supported. To reinforce his point, Vershinin promised to supply high-time RD-9B engines removed from MiG-19s for installation in the upgraded La-17 drones. Eventually Lavochkin gave in and agreed.

The RD-9BK engine intended for the drone's new version (alias RD-9K, the K standing for *korotkore**soors**nyy* – with a short service life) was developed by OKB-26 headed by V. N. Sorokin – the design office of aero engine factory No.26 in Ufa, Bashkiria – in 1958. Until 1955, when he was put in charge of his own design bureau, Sorokin

Judging by the markings on the tail, this early La-17 with no wingtip air bottle fairings has already survived three missions and is pictured after a fourth. Note the rear end of the engine nacelle flattened by the impact on touchdown and the wire aerials stretched between the tailplane tips and the fuselage.



A La-17M on its mobile launcher developed from an AA gun mount; note the wingtip fairings. The odd position of the launcher's front wheels (the drone sits back to front) are not the result of a broken axle; they are tilted like this so that the front end of the chassis rests on special supports.

had been an aide of Aleksandr A. Mikulin (who had fallen into disfavour at the top level) at OKB-300; he was also the RD-9B's chief project engineer. Unlike the baseline RD-9B, which was an afterburning turbojet, the RD-9BK lacked the afterburner and variable nozzle which were replaced by a simple tapered fixed-area nozzle. The engine control system incorporated a remote control unit, the engine speed being adjusted by push-buttons on the drone's launch control panel. For the sake of reliability the engine's maximum rating was restricted to nominal power (1,950 kgp/4,300 lbst).

The changes were not limited to the new powerplant. The upgraded drone received a more refined radio control system and a new AP-73 autopilot specially developed for *izdeliye* 203. The operational altitude envelope was expanded from 2,800-9,750 m (9,190-31,990 ft) to 3,000-16,000 m (9,840-52,490 ft).

The official go-ahead for the development of the *izdeliye* 203 drone came in July 1958 when the Council of Ministers issued an appropriate directive. The advanced development project (ADP) was completed before the end of the year; in 1959 plant No.301 set to work manufacturing fifteen flight test examples of the new drone plus a static test article. As intended, the mount of the KS-19 AA gun was converted into a launch ramp with an elevation of 20±10°; like the purpose-built four-wheel transportation dolly designed for the drone, it was towed by a YaAZ-214 or KrAZ-214 6x6 lorry. (Note: The two models are essentially the same vehicle. Production of lorries was transferred to MAZ in Minsk, Belorussia, and KrAZ in Kremenchug, the Ukraine, when the Yaroslavl' Automobile Factory (YaAZ) in Russia became the Yaroslavl' Engine Factory (YaMZ) in 1959, specialising henceforth in automotive diesels.)

Manufacturer's flight tests and state acceptance trials were held at the GK NII VVS facility at Vladimirovka AB in Akhtoobinsk; the first flight of the *izdeliye* 203 took place in September 1959. At 650 kg (1,430 lb), the new turbojet was more than twice as heavy as the earlier ramjet; on the other hand, it was much shorter, being 2.858 m (9 ft 4½ in) long, and the shorter engine nacelle was an obvious recognition feature. A major difference was that the RD-9BK ran on kerosene, Avgas being used only for starting; as a bonus, the slipstream-driven generator in the nose was augmented by an engine-driven generator.

The *izdeliye* 203 drone blasted off the ramp with the help of two PRD-98 solid-fuel rocket boosters (*porokho**voy** ra**ket**nyy **dviga**tel'*) attached to the sides of the engine pylon. The PRD-98 was a product of I. I. Kartookov's design team based at plant No.81 in Moscow; it had a 140-kg (310-lb) Ballistite propellant charge and delivered up to 10,600 kgp (23,370 lbst) of thrust, with a burn time between 1.6 and 3.1 seconds. The combined impulse of the two boosters was enough to accelerate the drone to more than 300 km/h (186 mph). Two pairs of delta-shaped fins set at an angle to the booster's axis were installed at the front and rear extremities of the body to assist separation after burnout.

The cruise engine ran at ground idle at the moment of launch; two seconds after launch a radio command was transmitted and the RD-9BK went to full power as the acceleration continued. Five seconds after launch the spent boosters were jettisoned and the aircraft transitioned to level flight, the engine throttling back to cruise power to save fuel; the cruise rating was 1,350 kgp (2,980 lbst) when measured on a bench or 630 kgp (1,390 lbst) in actual flight at 5,000 m (16,400 ft) and Mach 0.76. Thus in comparable flight modes the engines of the La-17 (*izdeliye* 201) and the upgraded *izdeliye* 203 had almost identical ratings.

After Semyon A. Lavochkin's sudden death on 9th June 1960 OKB-301 was headed by Mikhail M. Pashinin (best known for his unsuccessful I-21 fighter of 1940). In November 1960, having successfully completed its state acceptance trials, *izdeliye* 203 was included into the inventory under the service designation La-17M (*moderni**zee**rovannyy* – updated). Note that due to the programme's high importance the La-17M was officially included into the inventory, not just accepted for service (as had been the case with the La-17 *sans suffixe*). The new model superseded the original La-17 on the production lines of plant No.47 in Orenburg.

The launch weight of the La-17M increased to 2,472 kg (5,450 lb) in 'clean' condition or 3,065 kg (6,760 lb) with the boosters attached. Engine operation time increased to 34-39 minutes, extending the range to 490 km (304 miles); also, thanks to the greatly increased engine thrust the service ceiling rose to an impressive 16,000 m. On the other hand, the engine thrust in cruise mode could not be adjusted and the drone exceeded the dynamic pressure limit at low altitudes; hence for structural integrity reasons the minimum operational altitude had to be increased from 2,800 to 3,000 m.

For the first time in Soviet practice the La-17M's operational techniques included the relative speed method. With a top speed around 900 km/h (559 mph), the closing speed between the drone and the missile (or interceptor) depended on the angle from which it was shot at. In a head-on engagement this allowed a supersonic target to be simulated (the closing speed was in excess of Mach 1), while in pursuit mode the target's relative speed was of course much lower. The La-17M's longer endurance left plenty of room for 'cat and mouse games'. The drone would be attacked by two groups of fighters; the first group would fire inert air-to-air missiles, the telemetry equipment installed on the drone registering the distance by which they missed it (the AAMs had proximity fuses obviating the need for a direct hit), whereupon the second group would destroy the target with live AAMs.

The problem of the all-too-small RCS mentioned previously was easily cured. Both the La-17 *sans suffixe* and the La-17M could be fitted with Luneburg lenses (that is, angle reflectors) – one or two on each wing and one more on the fuselage tailcone – to increase the radar signature. Depending on the number of reflectors, this allowed the drone to

simulate both tactical bombers like the IL-28 or English Electric Canberra with an RCS around 8 m² (86 sq ft) and medium bombers like the Tu-16 or Boeing B-47 Stratojet with an RCS around 19-23 m² (204-247 sq ft). By comparison, the La-17's own RCS was only 0.6-1.7 m² (6.45-18.27 sq ft).

The La-17M stayed in production for six years and saw service with both the Air Force, the Army and the Navy. It enjoyed a well-earned reputation as a versatile, reliable and cheap target drone. In the early 1960s, however, new tactics appeared; the SAM threat made strike aircraft resort to low-level and ultra-low-level air defence penetration, and the La-17M's minimum operational altitude of 3,000 m no longer met the demands of the day.

La-17MA target drone (*izdeliye* 202)

Early-production La-17M drones lacked the autonomous control system (programmable autopilot). As early as June 1963, however, a version incorporating this feature passed its test cycle and superseded the La-17M in production as the La-17MA or *izdeliye* 202; the A suffix stood for *avto**nom**noye oopravl**en**iye* (autonomous control).

Operating in accordance with a preset programme from the moment of launch, the autopilot automatically jettisoned the solid-fuel rocket boosters, controlled the engine speed, stabilised the flight altitude and so on. The radio control capability was retained.

La-17MM target drone (*izdeliye* 202M)

The same Communist Party Central Committee/Council of Ministers joint directive of November 1960 that cleared the La-17M for service tasked OKB-301 with developing a more advanced version of the drone, which later became known as the La-17MM or *izdeliye* 202M. The specification called for an operational altitude envelope of 500-18,000 m (1,640-59,055 ft) and an RCS in the 3-cm waveband equal to that of the Tu-16 and IL-28 bombers and the FKR-1 cruise missile.

The chief difference between the La-17MM (*izdeliye* 202M) and the earlier La-17MA (*izdeliye* 202) was that the new version was powered by an RD-9BKR engine. The latter was identical in performance to the RD-9BK but featured a system limiting the engine rpm and accordingly the drone's maximum speed at low altitudes (based on inputs from the air data system) so that the dynamic pressure limit would be observed.

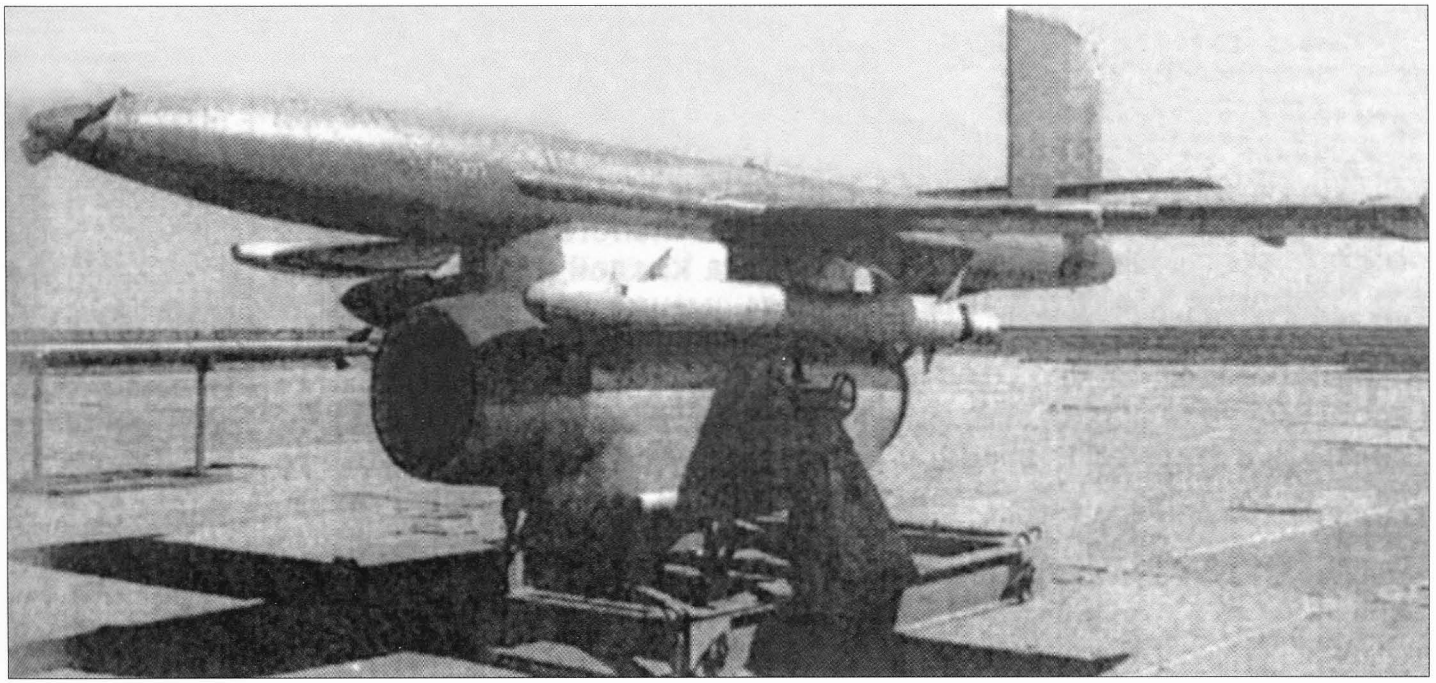
The La-17MM's tailcone was fitted with a reflector of 300 mm (11 13/16 in) diameter to provide the required RCS; the avionics suite included transponders allowing the drone's position to be determined more accurately with the help of P-30 radars or radars forming part of the Kama tracking system. In order to keep the drone on the desired track with acceptable accuracy, given the longer endurance, the AP-73 autopilot was replaced with a new AP-122 autopilot featuring an integration module in the heading channel.

The La-17MM had a new automatic landing system. In the event the drone was not shot down it entered a glide path; at the end of it a weight in the rear fuselage was ejected at minimum speed and altitude, pulling a safety pin. A special programme was thereby activated, the autopilot pulling the machine up into an extreme nose-up attitude, and the drone would start 'pancaking'. The engine nacelle occupied by the turbojet was no longer crushable, of course, so two energy-absorbing skids with a soft filler were attached to the underside of the nacelle to cushion the impact. These skids were then replaced, allowing the drone to be reused several times.

The state acceptance trials held at GK NII VVS (Vladimirovka AB) in October-December 1963 showed that the La-17MM's operational altitude envelope was 580-18,100 m (1,900-59,380 ft); the endurance varied from 32 minutes at minimum altitude to 97 minutes at the service ceiling. At high altitudes the La-17MM could go as fast as 875 km/h (543 mph); the landing speed was 270-300 km/h (167-186 mph) coupled with a sink rate of 5-6 m/sec (984-1,180 ft/min). All of this significantly enhanced the drone's ability to emulate aerial targets, including low-flying aircraft.

Upon completion of the trials the manufacturing documents for the La-17MM were transferred to plant No.47 in 1964. RD-9BKR engines were remanufactured at plant No.26, using components of time-expired RD-9Bs which had completed three 100-hour times between overhauls (TBOs) or two 150-hour TBOs. Even so, the 'new' engine's guaranteed service life was 30 hours – thrice that of the RD-9BK. In April 1965 plant No.26 started remanufacturing RD-9BK Srs 2 engines which incorporated the new features introduced on the RD-9BKR, differing only in having a 10-hour service life. Such engines were fitted to La-17MA and La-17M drones.

The La-17MM was the final version of the drone developed by OKB-301 (but not the last one, as it turned out) and was brought out after its founder's death.



A La-17MM (La-17K) target drone (c/n 410737) mounted in a fixture for ground testing. The larger nacelle of the R11K engine and its longer pylon are well visible, as are the PRD-98 solid-fuel rocket boosters with angled fins assisting separation.

The rocket boosters of an RD-9BK-powered La-17MM belch fire as it leaves the launcher; they will fall away from the drone in a couple of seconds.

La-17n target drone (*izdeliye* 201n)

When the La-17M entered production, a number of La-17 *sans suffixe* ramjet-powered air-launched drones was converted for ground launch in the manner of the later versions. Such examples were designated La-17n and bore the in-house product code *izdeliye* 201n; the 'n' suffix (stated in lower case in the documents of the day) stood for *na**zem**nyy start* – ground launch. The airframe of the La-17n was reinforced to absorb the high forces generated by the rocket boosters and an autonomous control system similar to that of the La-17MA was fitted. The drone took off on the thrust of the PRD-98 boosters alone; a couple of seconds later the autopilot's time delay mechanism ignited the ramjet sustainer and jettisoned the boosters as they burned out, whereupon the flight proceeded in accordance with the programme.

La-17R reconnaissance drone project (first use of designation; *izdeliye* 210-FR)

The idea of using UAVs for aerial reconnaissance dates back to the late 1930s and was first implemented in Germany in 1939 when a pilotless reconnaissance aircraft was tested at the *Erprobungsstelle* Rechlin. However, the concept was not developed further and used operationally until the 1960s, when the rapid development of air defence systems meant that spyplanes were no longer immune at any altitude. It was then that the Soviet Union and the USA started developing and fielding unmanned aerial reconnaissance systems. Hence, once development of the La-17 target drone had been completed, the perfectly logical idea arose of turning it into a pilotless reconnaissance aircraft capable of reconnoitring heavily protected (or heavily contaminated) areas that were too dangerous for manned aircraft. Nuclear contamination was an important factor; from the early 1950s onwards it was believed that any future war would be fought in a nuclear scenario (fortunately this was not the case), and radiation levels also needed to be measured during nuclear tests.

Pursuant to a Council of Ministers directive issued in June 1956 OKB-301 was to modify the La-17 into a reconnaissance drone provisionally referred to as *izdeliye* 210-FR (***fot**orazved**chik*** – photo reconnaissance aircraft) or La-17R. The aircraft was to be fitted with an AFA-BAF-40R camera with a focal length of 400 mm (15¾ in) on a tilting mount for two-strip vertical photography. (AFA = ***a**ero**fot**oappa**raht*** – aircraft camera.) The Luneburg lenses were deleted and the drone's dielectric wingtips were replaced with metal ones.

Like the original target drone version, the La-17R was to be air-launched; the estimated range when cruising at 7,000 m (22,965 ft) exceeded 170 km (105 miles). However, due to the shortcomings of the air-launched version described earlier the *izdeliye* 210-FR was not proceeded with.

La-17BR reconnaissance drone project

In February 1958 OKB-301 was tasked with developing another reconnaissance version of the La-17 designated La-17BR (*bespi**lot**nyy raz**ved**chik* – pilotless reconnaissance aircraft). Like the previous version, this was air-launched, with a modified Tu-4 acting as the 'mother ship', but differed in having much longer range (the combat radius was to be at least 100 km/62 miles). By then, however, the La-17 *sans suffixe* and the air launch concept were outdated; from the end of 1959 onwards all further work on the La-17BR proceeded on the assumption that the aircraft would be based on the ground-launched La-17M powered by the RD-9BK turbojet.

TBR-1 tactical unmanned aerial reconnaissance system:

La-17R recce drone (second use of designation; izdeliye 204)

Development of the second version to bear the La-17R designation began in 1958-59; known at the OKB as *izdeliye* 204, this was derived from the La-17M. Outwardly and structurally the La-17R differed little from the

latter. The most obvious recognition feature was the forward fuselage stretched by 0.54 m (1 ft 9$^{17}/_{64}$ in) and having a shallow flat-bottomed ventral bulge incorporating two optically flat camera ports, as the camera lenses were too long to be housed completely inside the circular fuselage cross-section. Another identification feature was the absence of the cigar-shaped wingtip fairings housing compressed air bottles; this was because the reconnaissance version was to operate at much lower altitudes than the target drone and the required air supply was smaller.

The production La-17R had several alternative camera fits. These included the AFA-20 (f = 200 mm/7⅞ in), the AFA-BA-40 (f = 400 mm) and the AFA-BAF-21 (f = 210 mm/8$^{17}/_{64}$ in) for vertical strip photography. The latter two models had a high optical resolution (60 lines/mm) and were in quantity production for Soviet reconnaissance aircraft. The AFA-BA-40 was a high-altitude camera capable of covering a 15x15 km (9.3x9.3 mile) piece of terrain, while the AFA-BAF-21 was optimised for low-level operations and able to cover an area between 3x3 and 4x4 km (1.86x1.86 to 2.48x2.48 miles). Other possible equipment fits were the AShchAFA-5E or AShchAFA-5M slot camera for panoramic photography, the ***Chi**bis* (Lapwing) TV camera or the Sigma radiation reconnaissance kit. Depending on the mission equipment installed, the La-17R's empty weight (less fuel) varied between 1,624 and 1,698 kg (3,580-3,740 lb).

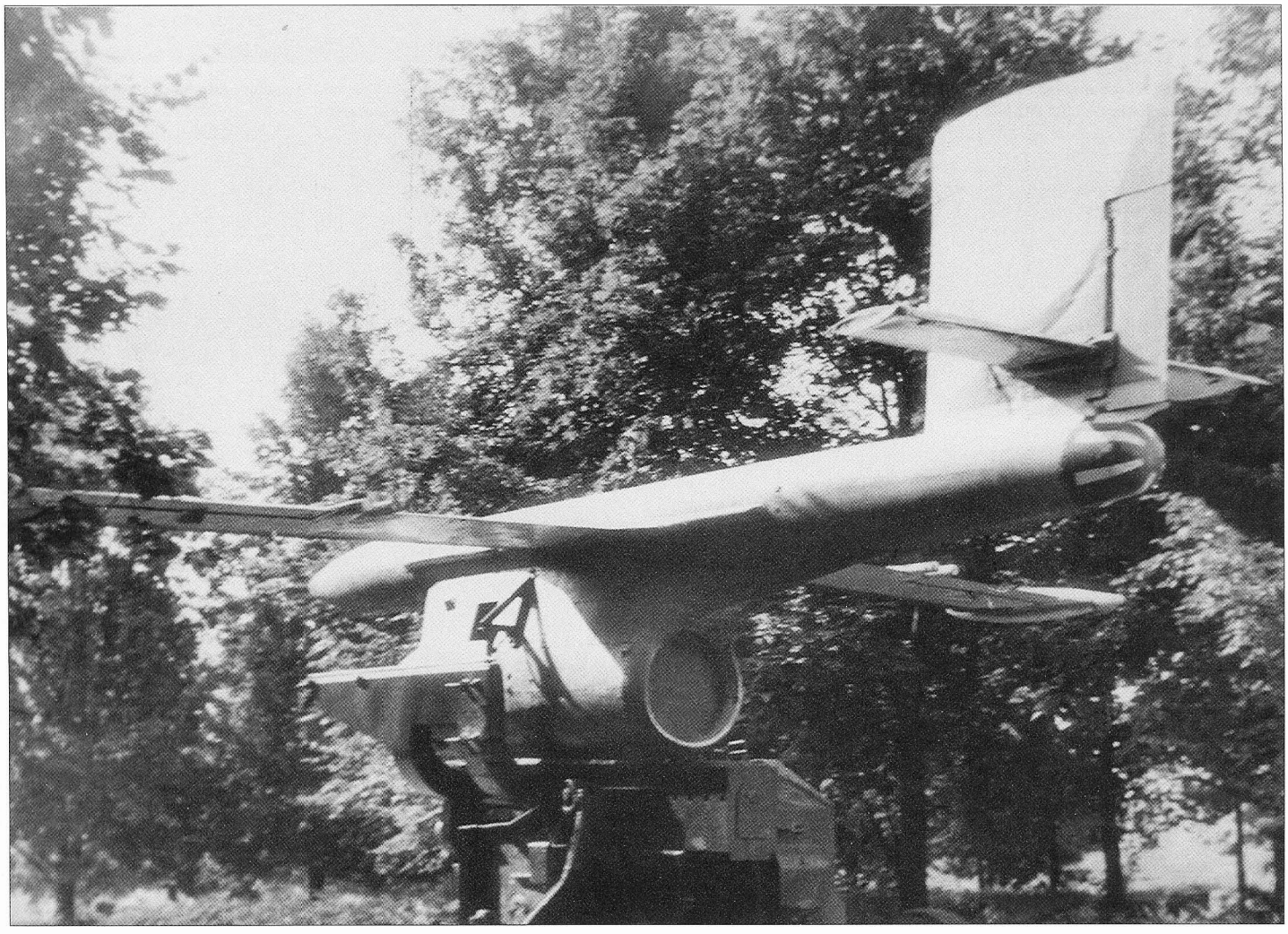
Two pairs of wire aerials ran from the wingtips to the forward and rear fuselage sides; the forward pair served the radio control system, while the rear one was for the RTS-8A electronic system. The rear fuselage housed the AP-63 autopilot, later replaced by the AP-118 and then by the AP-122. The tailcone accommodated the SO-129-P transponder whose antenna was located at the tip of the fin.

Unlike the target drones, the reconnaissance version was not expendable. Therefore the La-17R was powered by the RD-9BKR engine having the longest possible service life.

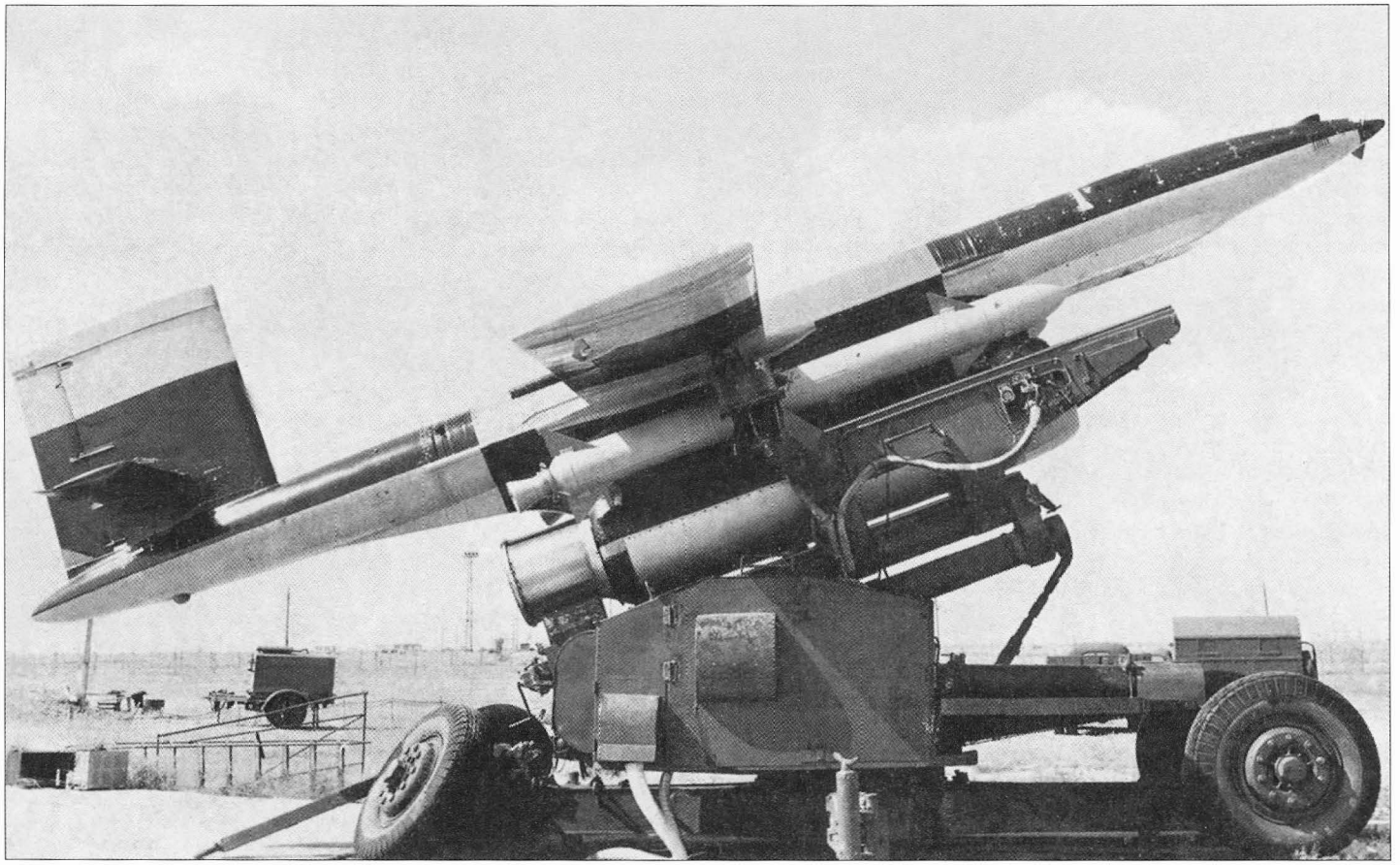
A new transporter/erector/launcher vehicle (TEL) was developed for the La-17R (izdeliye 204). Designated SATR-1 (***star**tovyy avtomo**bil'** tak**tich**eskovo raz**ved**chika* – 'automobile-mounted tactical recce aircraft launcher'), it was based on the Moscow-built ZiL-134K high-mobility 8x8 chassis with steerable front and rear axles which was originally a TEL for the *Lu**na**-M* (Moon-M) theatre ballistic missile. Hence the La-17R incorporated a wing and tail unit folding feature to make sure it would fit inside the dimensions of the TEL in transport configuration.

The launch sequence was controlled from the driver's cab of the SATR-1. The La-17R took off with the assistance of two PRD-98 rocket boosters, flew over the area to be reconnoitred in accordance with the programme entered into the autopilot and returned to the designated landing area.

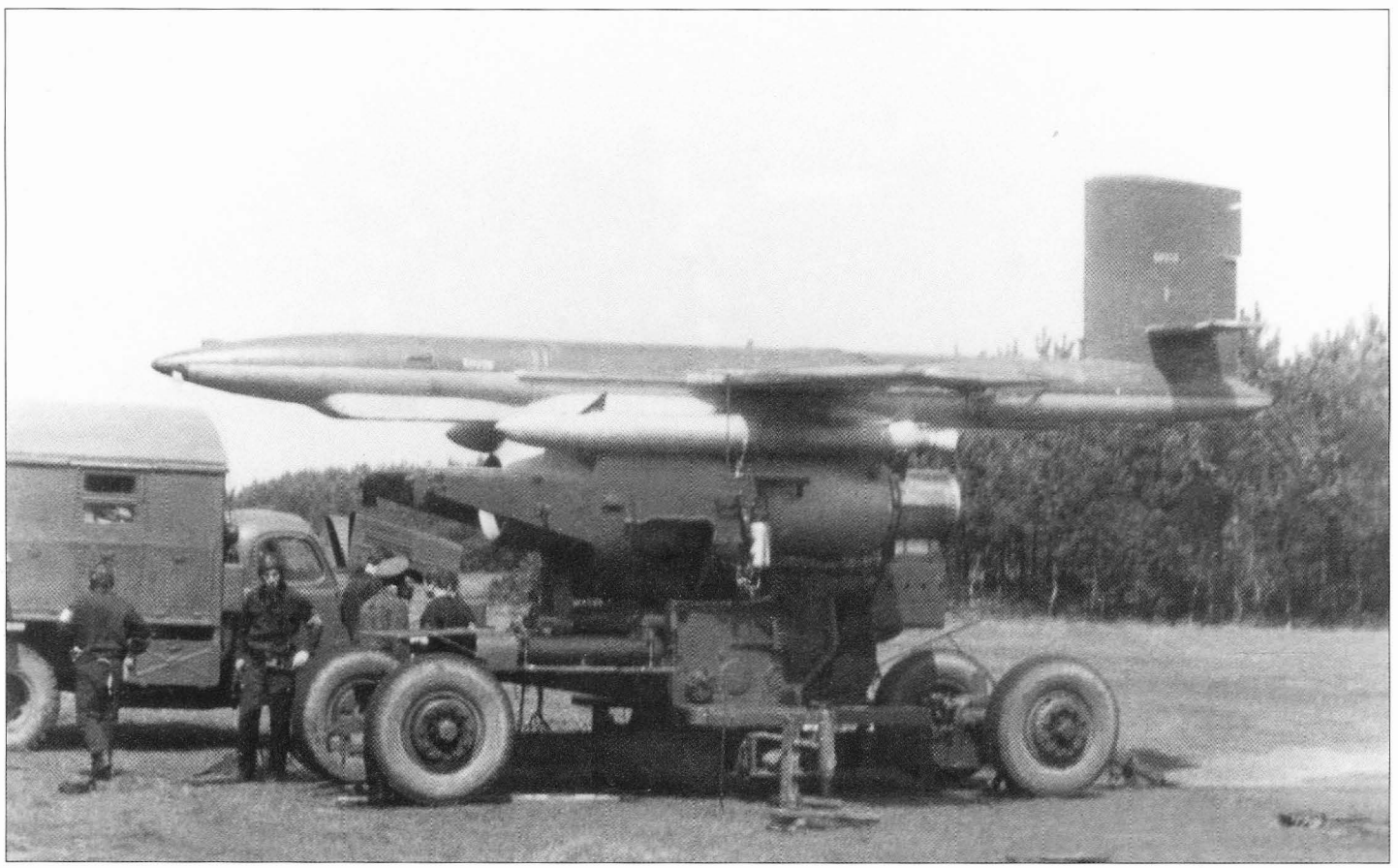
The La-17R's entire test programme was performed at GK NII VVS in Akhtoobinsk, lasting until 1962. As was the case with the La-17M (*izdeliye* 203), the prototypes were launched from a modified AA gun mount, subsequently landing on their engine nacelles, and lacked the wing/tail unit folding feature – probably because they had been converted from stock La-17Ms. The combat radius was shown to be around 400 km (250 miles). Interestingly, the very much larger Tu-123 Yastreb supersonic reconnaissance UAV (see Chapter 2) was also undergoing tests in Akhtoobinsk at the same time.



This La-17MM is preserved at a Soviet Army garrison in Tula. Note the SO-129-P ATC/SIF transponder in the tailcone.

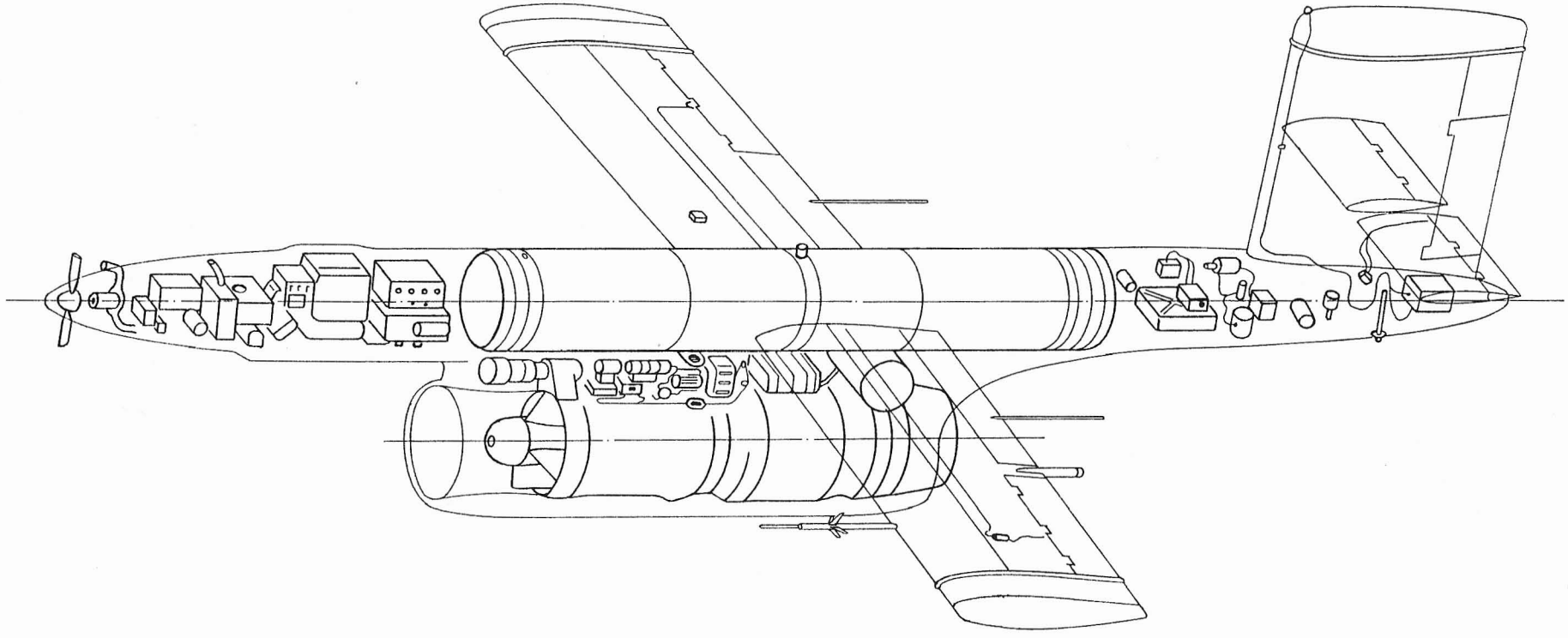


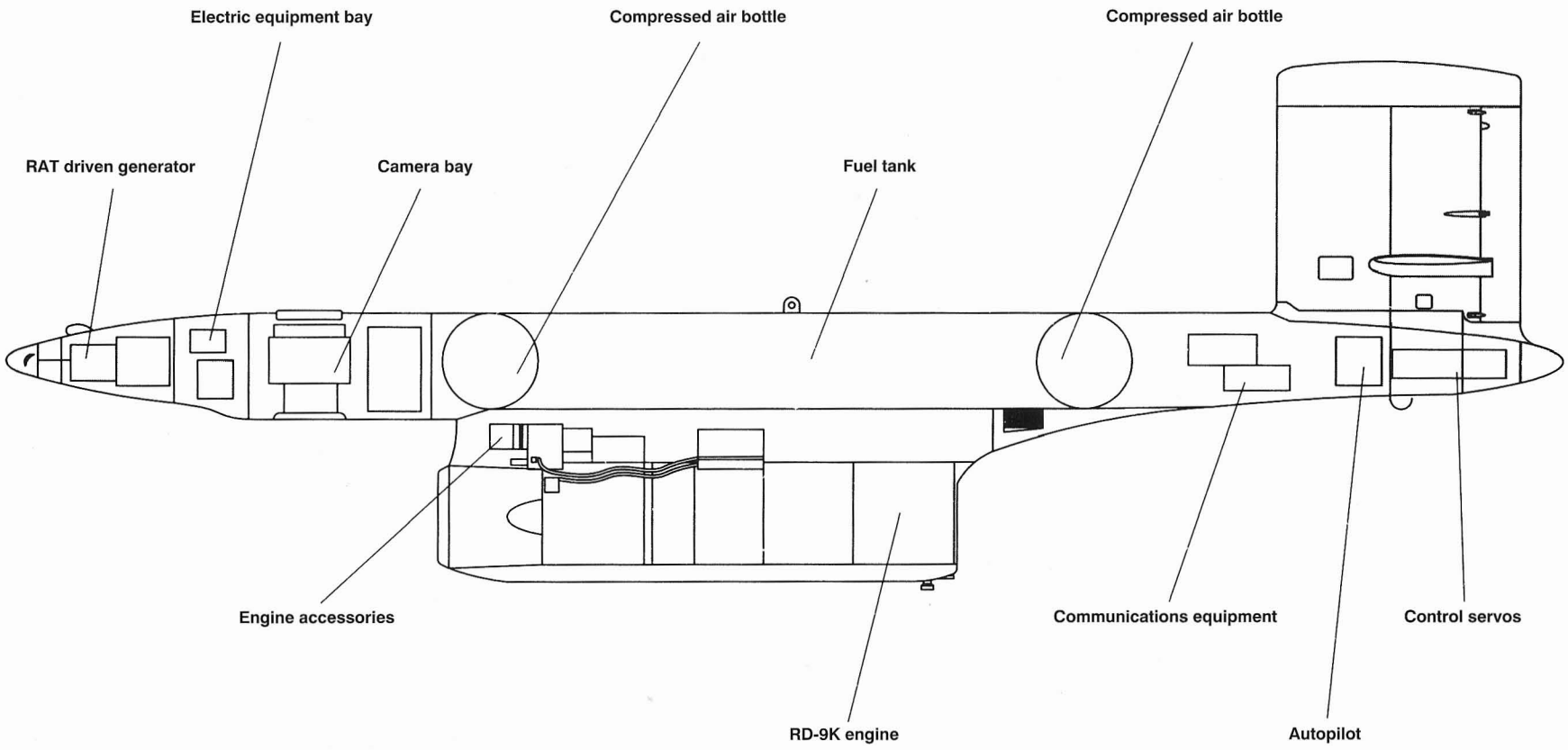
Above: The La-17R reconnaissance drone prototype in high-visibility black and yellow colours on its SUTR-1 launcher with boosters attached. Note the long and shiny extension jetpipe of the RD-9BKR engine and the longer forward fuselage with a camera window fairing underneath.



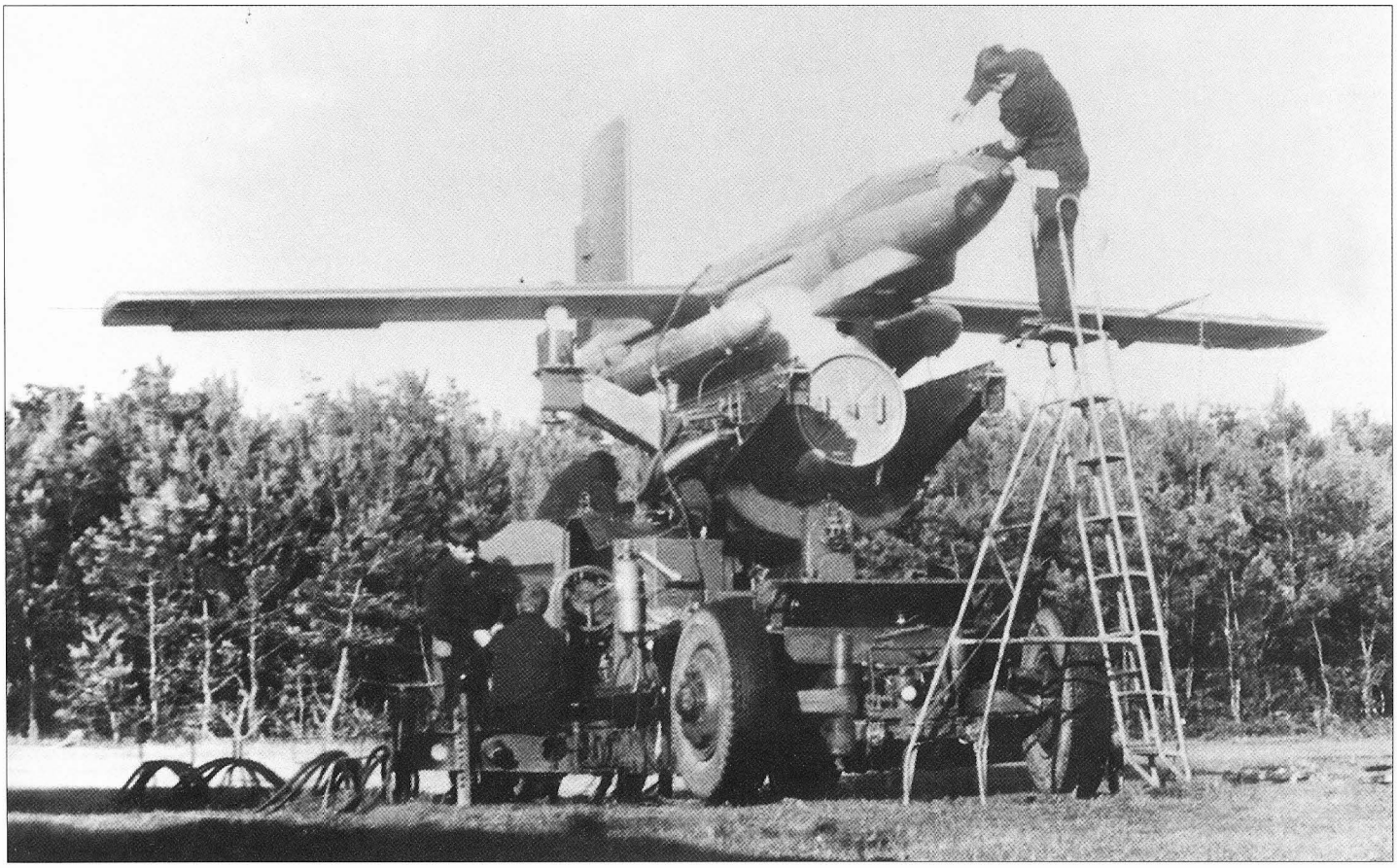
A production La-17R (c/n 50326) has been moved into position for launch. Unlike the drone versions, production La-17Rs wore a green/pale blue camouflage scheme. The ZiL-164 with a van body visible in the background is a KATR-1 support vehicle with test equipment and a generator for engine starting.

A cutaway drawing of the La-17R reconnaissance drone.





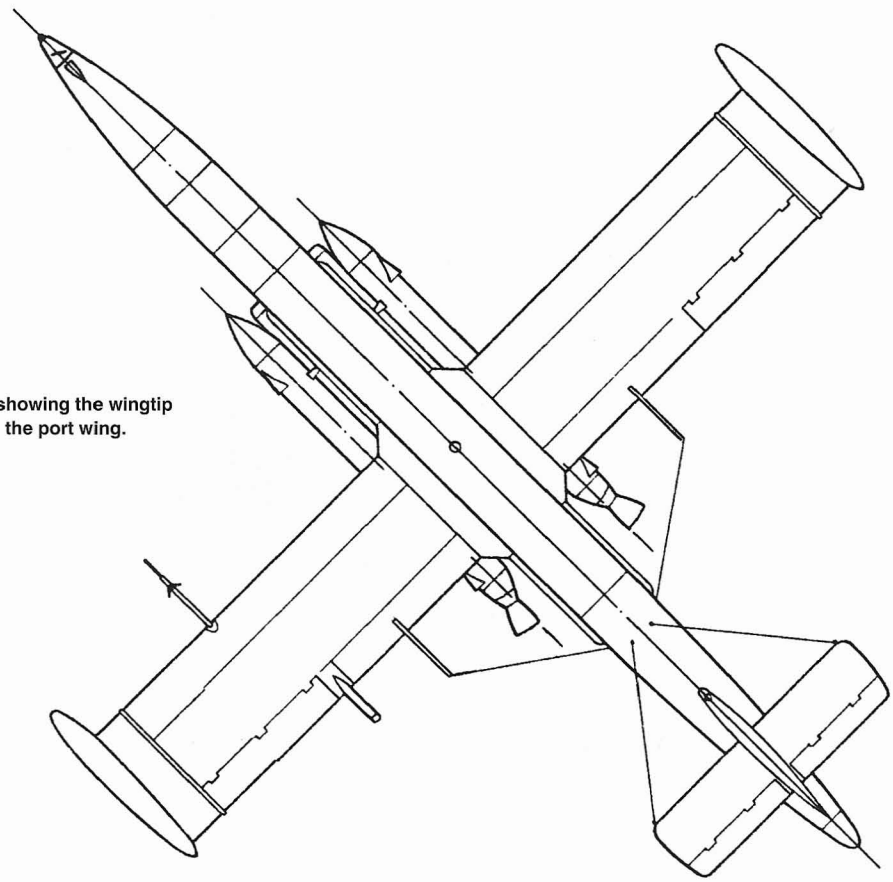
Drawing of the La-17R reconnaissance drone.



Above: Preparations are in hand to launch La-17R c/n 50326; technicians swarm all over the launcher and the drone.

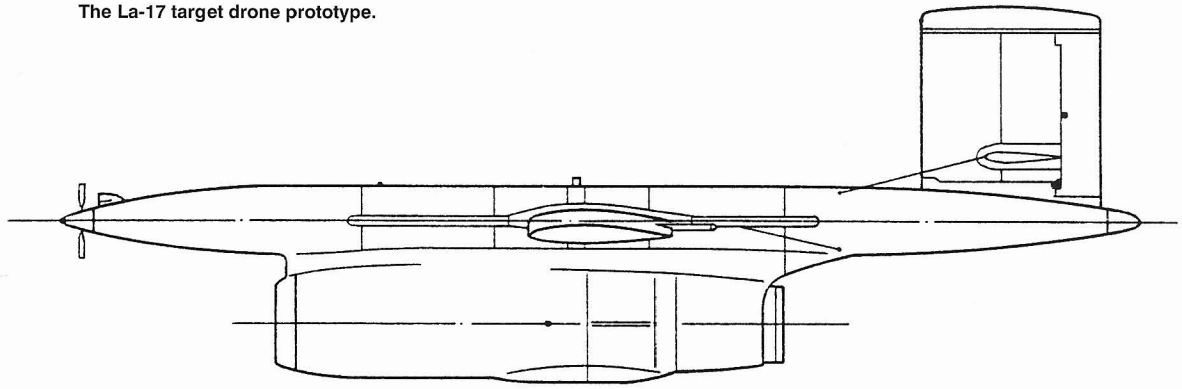
Here, the air intake cover has been removed, revealing the RD-9BK engine's fixed spinner.

Above: Pictured here in September 1995, this La-17RM (c/n 50115) was on display at the open-air museum at Moscow-Khodynka complete with its ground fixture. This view illustrates the cruise engine nozzle (which is damaged on this example) and the rear attachment struts of the PRD-98 rocket boosters.

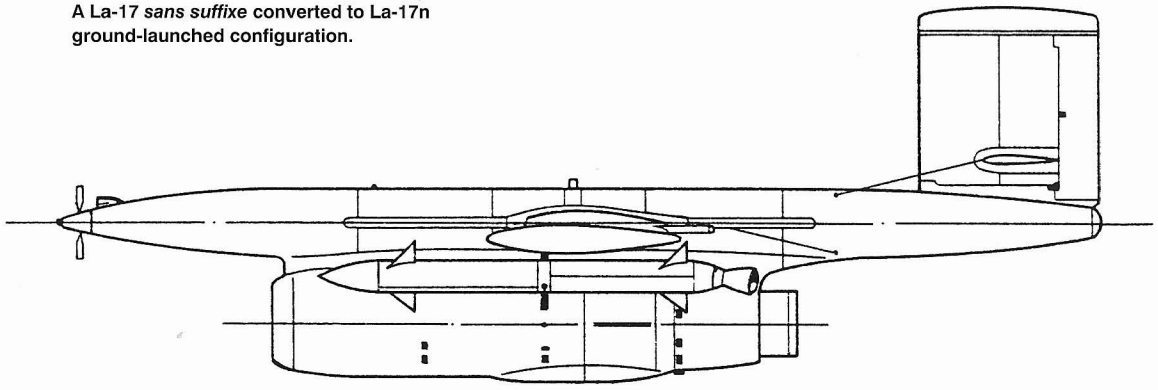


Upper view of a La-17M, showing the wingtip fairings and the tracer on the port wing.

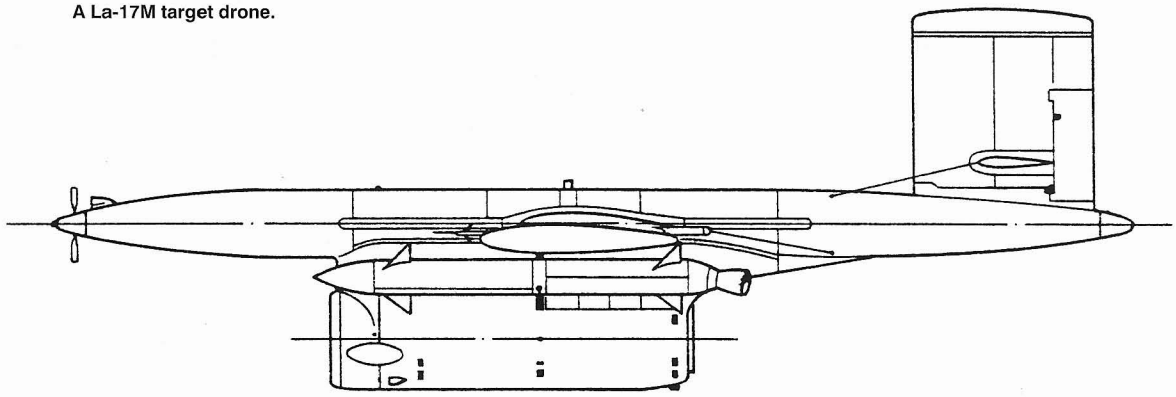
The La-17 target drone prototype.



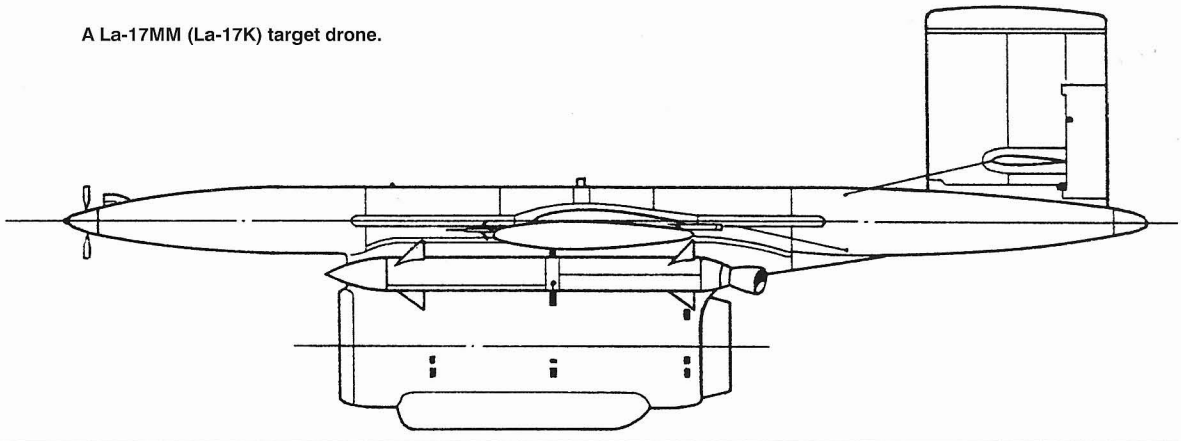
A La-17 *sans suffixe* converted to La-17n ground-launched configuration.



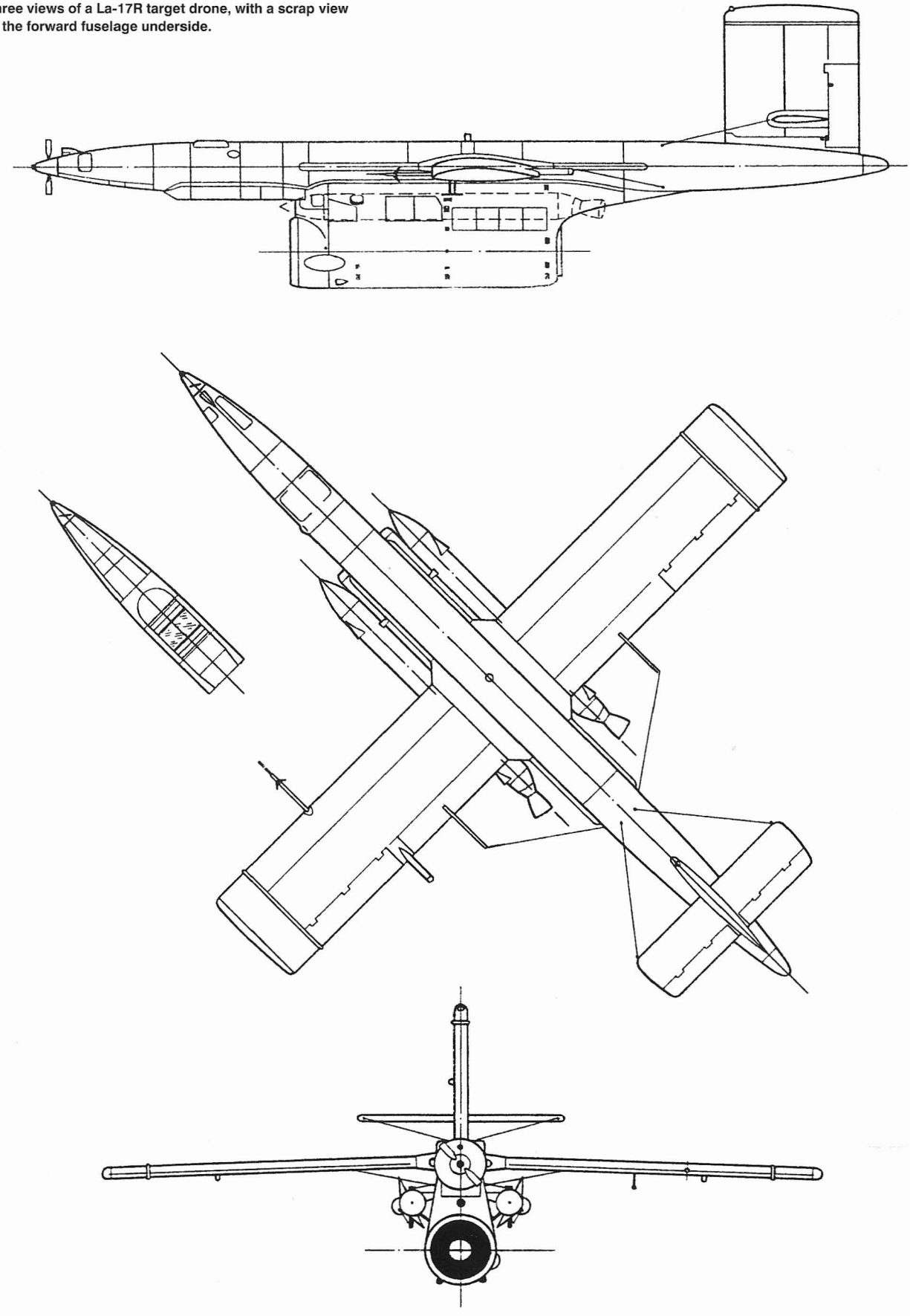
A La-17M target drone.



A La-17MM (La-17K) target drone.



Three views of a La-17R target drone, with a scrap view of the forward fuselage underside.



Thus by 1962 the Soviet Union finally came into possession of its first tactical unmanned aerial reconnaissance system designated TBR-1 (*tak**tich**eskiy bespi**lot**nyy raz**ved**chik*). The system was designed for photographing enemy facilities and installations from low and medium altitudes in the daytime and in clear weather. Unlike the target drone versions, the La-17R (*izdeliye* 204) was produced by aircraft factory No.475 in Smolensk; production La-17Rs wore a foliage green camouflage scheme with greyish blue undersurfaces and no national insignia.

A complete La-17R (TBR-1) launch detachment comprised the following components:

• a SUTR-1 mobile launch ramp (***star**tovaya oosta**nov**ka tak**tich**eskovo raz**ved**chika* – tactical reconnaissance aircraft launcher) towed by a KrAZ-214 or KrAZ-255 heavy-duty 6x6 lorry;

• a number of TUTR-1 transport trailers (***trahns**portnaya oosta**nov**ka tak**tich**eskovo raz**ved**chika*) with La-17R UAVs towed by ZiL-157 (or the later ZiL-131) medium-duty 6x6 army lorries;

• a KATR-1 test lab/ground power unit (***kom**pleksnyy avtomo**bil'** tak**tich**eskovo raz**ved**chika* – combined [support] automobile for the tactical reconnaissance aircraft') based on a ZiL-164 5-ton 4x2 lorry with a van body. It was used for testing the UAVs' systems and cranking up the cruise engine prior to launch, hence the 'combined' bit;

• the ground components of the MRV-2M radio control system and the Amur (or Kama) radar tracking system.

The detachment also included some other equipment. Its mobility was severely hampered by the low towing speed of the SUTR-1 launch ramp converted from the carriage of the KS-19 AA gun, which could not go faster than 20 km/h (12.4 mph) because the tyres were made of solid rubber.

An Independent Pilotless Reconnaissance Squadron consisted of two such launch detachments, a maintenance shop (operating equipment test vans, mobile cranes and other hardware), a recovery team responsible for guiding the UAV to the designated landing area and recovering the exposed film or particle filter, and other detachments with their equipment.

When the TBR-1 system was deployed, a maintenance area and a launch pad were set up. At the former location the UAVs taken out of storage were returned to active status and preliminary pre-flight procedures and checks performed. At the launch pad a crane lifted the La-17R off the trailer and placed it on the launch ramp, whereupon the final checks were made, the autopilot was programmed, the fuel and oil tanks were filled and the air bottles charged to nominal pressure.

The La-17R could fly its mission in autonomous or radio control mode (that is, as a drone or as an RPV). In autonomous mode the changes of heading and altitude, engine rpm control and operation of the cameras were effected by a programmed time delay mechanism. In so doing the radio control system receiver would be switched on periodically in order to make mid-course heading corrections based on the aircraft's actual position determined by the tracking radars. The autopilot served for stabilising the aircraft in pitch, yaw and roll and making control inputs based on signals from the time delay mechanism or the radio control channel.

In radio control mode the La-17R was controlled by a navigator sitting in a map van; the Amur radar would constantly show the drone's position by 'painting' the aircraft and receiving coded return signals from the SO-129-P transponder. In case of need the navigator altered the RPV's course and 'fired' the cameras by transmitting appropriate commands.

Photographic reconnaissance (PHOTINT) missions were flown at altitudes between 600 and 7,000 m (1,970-22,965 ft). When flown at 600 m, the La-17R could reconnoitre objectives 60-80 km (37-50 miles) behind enemy lines; at 5,000-7,000 m (16,400-22,965 ft) this distance increased to 150-200 km (93-124 miles). The launch pad in these cases would be 20 km (12.4 miles) from the forward line of own troops (FLOT).

The La-17R recce drone landed in the same manner as the La-17M target drone, except that the flight path could be corrected by radio. The landing speed was 250-300 km/h (155-186 mph).

The aircraft was 8.435 m (27 ft 8⅝ in) long, measuring 2.98 m (9 ft 9²¹⁄₆₄ in) 'from heel to head' – that is, from the bottom of the engine nacelle to the tip of the fin; the launch weight was up to 2,840 kg (6,260 lb) with ordinary cameras or 2,915 kg (6,250 lb) if the AShchAFA-5E slot camera was fitted. Endurance was 45 minutes at 7,000 m or 35 minutes at 750 m (2,460 ft). The other performance parameters were identical to those of the La-17M target drone.

The La-17R (TBR-1) tactical reconnaissance drone stayed in production until 1974 when it was succeeded by a more modern type – the VR-3 Reys developed by Andrey N. Tupolev's OKB-156 (see next chapter).

In the 1960s Independent Pilotless Reconnaissance Squadrons equipped with the TBR-1 weapons system were established in Khar'kov and Kamenka-Boogskaya in the Ukraine, in Beryoza Kartoozskaya in Belorussia and in Madona in Latvia (*their* spelling). The TBR-1 system remained on the Soviet Air Force inventory for nearly 20 years, the last examples being withdrawn in the early 1980s.

La-17RM reconnaissance drone (*izdeliye* 204M)

An updated version of the La-17R was brought out in 1965, entering production as the La-17RM (*raz**ved**chik moderni**zee**rovannyy* – updated reconnaissance aircraft) or *izdeliye* 204M. It incorporated many of the design features introduced on the La-17MM (*izdeliye* 202M).

A La-17R (c/n 50115) was on display at the open-air museum at Moscow's Central Airfield named after Mikhail V. Frunze (better known as Moscow-Khodynka) since at least September 1995. Unfortunately the museum closed in 2003 and the fate of the exhibits is uncertain.

La-17RU standardised reconnaissance drone (*izdeliye* 204U)

The La-17R (*izdeliye* 204) also evolved into a version designated La-17RU (*izdeliye* 204U). The U stood for *oonifi**tsee**rovannyy* (standardised); in this context it meant that the La-17RU had maximum structural and technological commonality with the drone version, which reduced manufacturing and operating costs.

La-17UM standardised target drone (*izdeliye* 204UM)

The other standardised version was the La-17UM target drone (*izdeliye* 204UM); 'UM' stood for *oonifi**tsee**rovannaya mi**shen'***. It differed from the La-17RU in lacking the cameras and being powered by a shorter-life RD-9BK Srs 2 *et seq* instead of an RD-9BKR; the airframe and the other systems were identical for both versions.

Upgraded La-17MM target drone (La-17K)

The final indigenous version of the La-17 appeared in the mid-1970s, but it was no longer a Lavochkin product. The former OKB-301, now known as the Scientific & Production Association named after S. A. Lavochkin, had been transferred from the Ministry of Aircraft Industry (MAP – *Mini**ster**stvo aviatsi**on**noy pro**mysh**lennosti*) to the Ministry of General Machinery (MOM – *Mini**ster**stvo **ob**schchevo ma**shin**ostro**yen**iya*), the industry responsible for the Soviet space and missile programmes, back in 1965 and reoriented towards developing space launch vehicles (SLVs). True, work on target drones continued for another two years after this reshuffle but then the design team concentrated entirely on rocketry. Concurrently, in 1967, all design documentation for the La-17 was transferred to plant No.47 in Orenburg (already known as the Strela plant).

However, as time passed the available stocks of RD-9B and RD-9BF engines used for remanufacturing into RD-9BKs ran out and

Basic specifications of the La-17 family

	La-17	La-17M	La-17MA	La-17n	La-17R	La-17MM (La-17K)
Product code	*Izdeliye* 201	*Izdeliye* 203	*Izdeliye* 202	*Izdeliye* 201n	*Izdeliye* 204	*Izdeliye* 202M
First flight	1953	1959	1961	1962	1962	1977
Cruise engine	RD-900	RD-9BK	RD-9BK Srs 2	RD-900	RD-9BKR	R11K
Thrust, kgp (lbst)*	1,950 (4,300)	2,450 (5,400)	2,450 (5,400)	1,950 (4,300)	2,450 (5,400)	2,450 (5,400)
Boosters	–	PRD-98	PRD-98	PRD-98	PRD-98	PRD-98
Engine length	4.085 m (13 ft 4⁵⁄₆₄ in)	2.858 m (9 ft 4½ in)	2.858 m (9 ft 4½ in)	4.085 m (13 ft 4⁵⁄₆₄ in)	2.858 m (9 ft 4½ in)	2.33 m (7 ft 7⁴⁷⁄₆₄ in)
Engine diameter	900 mm (2 ft 11⁷⁄₁₆ in)	665 mm (2 ft 2⁹⁄₁₆ in)	665 mm (2 ft 2⁹⁄₁₆ in)	900 mm (2 ft 11⁷⁄₁₆ in)	665 mm (2 ft 2⁹⁄₁₆ in)	906 mm (2 ft 11²¹⁄₃₂ in)
Length overall	8.435 m (27 ft 8⅝₄ in)	8.435 m (27 ft 8⅝₄ in)	8.435 m 27 ft 8⅝₄ in)	8.435 m 27 ft 8⅝₄ in)	8.979 m (29 ft 5½ in)	8.435 m (27 ft 8⅝₄ in)
Height	n.a.	2.98 m (9 ft 9²¹⁄₆₄ in)	2.98 m (9 ft 9²¹⁄₆₄ in)	n.a.	2.98 m (9 ft 9²¹⁄₆₄ in)	n.a.
Wing span	7.5 m (24 ft 7⅝₂ in)	7.5 m (24 ft 7⅝₂ in)	7.5 m (24 ft 7⅝₂ in)	7.5 m (24 ft 7⅝₂ in)	7.5 m (24 ft 7⅝₂ in)	7.5 m (24 ft 7⅝₂ in)
Fuselage diameter	0.55 m (1 ft 9²¹⁄₃₂ in)	0.55 m (1 ft 9²¹⁄₃₂ in)	0.55 m (1 ft 9²¹⁄₃₂ in)	0.55 m (1 ft 9²¹⁄₃₂ in)	0.55 m (1 ft 9²¹⁄₃₂ in)	0.55 m (1 ft 9²¹⁄₃₂ in)
Launch weight, kg (lb):						
without boosters	1,810 (3,990)	2,472 (5,450)	n.a.	n.a.	n.a.	n.a.
with boosters	–	3,065 (6,760)	n.a.	2,410 (5,310)	2,840-2,915 (6,260-6,425)	3,100 (6,830)
Top speed at 7,000 m (22,965 ft), km/h (mph)	900 (559)	880 (546)	880 (546)	900 (559)	880 (546)	900 (559)
Service ceiling, m (ft)	10,000 (32,810)	17,000 (55,770)	17,000 (55,770)	10,000 (32,810)	7,000 (22,965)	17,500 (57,410)
Endurance, minutes	40	60	60	40	45	60
Range, km (miles)	n.a.	490 (304)	n.a.	n.a.	260 (161)	n.a.

* On a bench

production of the latter version had to be terminated in 1979 – which, in turn, led to the termination of La-17 production. Of course, from the standpoint of the military this was no reason to give up using the La-17, and operations with the target drones continued as actively as ever. The only option in these circumstances was to re-engine the La-17; however, this required a serious design effort. Since the Orenburg plant was not in a position to take on the task, a different 'contractor' had to be sought.

As regards the engine type, the main customer (the Air Force) proposed fitting the drones with Tumanskiy R11F-300 axial-flow turbojets being removed from early versions of the MiG-21 fighter which were being phased out. The Air Force approached the Kazan'-based State All-Union Sports Aviation Design Bureau (later renamed the Sokol OKB), suggesting this establishment should undertake the redesign of the La-17 to take the new engine.

At that point the Council for Mutual Economic Assistance (SEV – *Sovet ekonomicheskoy vzaimopomoshchi*, the Eastern Bloc's counterpart of the EEC) and the top command of the Warsaw Pact Organisation decided to concentrate development and production of sports aircraft and lightplanes in Poland, Czechoslovakia and East Germany. Hence the State All-Union Sports Aviation Design Bureau, which had specialised in glider and sailplane design, was forced to look for a new field of activity – and found it. First the design team from Kazan' developed a drone control aircraft based on the Czech-built Aero L-29 Delfin jet trainer; subsequently they concentrated on converting obsolete jets being phased out by the Air Force into radio-controlled target drones. Thus appeared the M-21 and the M-29 based on the MiG-21PF/MiG-21PFM and the L-29 respectively; later the Sokol OKB brought out the *Kometa* (Comet) towed target and associated podded towing winch custom-made for the Sukhoi Su-25BM target tug.

The OKB's Chief Designer A. I. Osokin and preliminary design (PD) projects section chief V. I. Paloogin went to Orenburg to get a better idea of the new subject which the Air Force wanted them to tackle. After discussing the details of the future redesign with V. Nesterov, head of the Strela plant's special design office, and an Air Force representative the designers from Kazan' and Orenburg came to the conclusion that the idea of re-engining the La-17 with the R11F-300 turbojet was feasible, and a report to this effect was sent 'upstairs'.

In 1974, in keeping with an appropriate Communist Party Central Committee/Council of Ministers directive, the Ufa-based OKB-26 aero engine design bureau – then headed by Chief Designer S. A. Gavrilov – developed and began testing the R11K-300 turbojet. More commonly known simply as the R11K (which is fair enough, since it was not a product of OKB-300 anymore), this was a non-afterburning short-life derivative of the R11F-300 two-spool afterburning turbojet. A short while later, on 14th May 1975, the Soviet Air Force endorsed the specific operational requirement (SOR) for the new version of the drone after OKB-26 had supplied the estimated performance figures for the modified engine.

No drastic design changes were made to the re-engined drone which was known at the Sokol OKB as the La-17K (the K may be a reference to the redesign undertaken in Kazan'). The biggest change to the airframe concerned the engine nacelle which was slightly enlarged to suit the new engine; the R11K was 0.53 m (1 ft 8⁵⁵⁄₆₄ in) shorter than the RD-9BK but had a 0.1 m (3⁵⁵⁄₆₄ in) greater inlet diameter. Apart from the size of the nacelle, the La-17K was readily identifiable by the characteristic fairing at the bottom of the nacelle enclosing the engine's accessory gearbox and piping.

The rocket booster attachment fittings were altered; revisions were made to the fuel system and the electrical system. The La-17K's higher all-up weight necessitated additional aerodynamic and structural strength calculations, including flutter calculations. Changes were also made to the autopilot and the ground support equipment. In a nutshell, almost every aspect of the La-17's design received the attention of the Kazan' engineers.

With regard to these changes the Sokol OKB completed a new set of manufacturing documents, drew up a new operating manual and built four prototypes of the La-17K for the flight test programme in 1975-77. The first flight of the upgraded drone took place in June 1977. As compared to the standard La-17MM, the improvement in performance was minor. The maximum RCS reached 40 m^2 (430 sq ft); maximum endurance was 1 hour. The La-17K had a turn radius of 6.8-7.6 km (4.2-4.7 miles) with 40° bank and 9.7-10.8 km (6.0-6.7 miles) with 20° bank. The launch weight amounted to 3,100 kg (6,830 lb), including 580 kg (1,280 lb) of fuel and an oil supply of 11 litres (2.42 Imp gal).

The La-17K entered production in Orenburg in 1978. For some reason the military chose not to allocate a new service designation, and the re-engined drones were still referred to as La-17MMs. In this guise the drone stayed in production all the way until 1993 when production was terminated – both on cost grounds and because a new target drone developed by the Sokol OKB (the Dan'; see Chapter 5) was due to enter production.

A peculiarity of the La-17MM (La-17K) was that several versions of the R11K engine were fitted, and these depended on the version of the original engine from which the R11K had been remanufactured. Frequently the engines were non-interchangeable and required minor alterations to be made to the engine nacelle. This warrants a more detailed description.

As was the case with the RD-9BK, the R11K was assembled from reconditioned parts of R11F-300 engines which had completed several TBOs. The numerous versions of the R11F-300 powered the MiG-21 fighter and the Su-15 interceptor. In the case of the R11K the afterburner and variable nozzle were replaced by a simple tapered fixed-area nozzle, as on the RD-9BK; the engine speed was adjusted via a remote control system by push-buttons on the drone's launch control panel. As a weight-saving measure, some of the baseline engine's systems were deleted; still, the R11K was 290 kg (640 lb) heavier that the RD-9BK. Again, as in the case of the RD-9BK, the maximum rating was restricted to 2,450 kgp (5,400 lbst). As distinct from the RD-9, the new engine ran on kerosene only (Avgas was no longer used for starting).

The first R11Ks were remanufactured from late-model R11F2-300s and subsequent versions. Later, two more versions appeared which were assembled from parts of older engines: the R11K1 assembled from parts of R11F-300 Srs 5 through Srs 7 engines and the R11K2 remanufactured from R11F-300 Srs 8 through Srs 10 engines. These two versions were interchangeable but neither was interchangeable with the original R11K, which had differently placed piping connectors. Hence minor changes were made to the La-17MM (La-17K) to suit the specific engine model.

From 1981 onwards the R11AK engine was produced in parallel for the La-17MM (La-17K); this version was remanufactured from R11AF-300 and R11AF2-300 engines removed from Yak-28 tactical aircraft after running out of TBOs or reaching the limit of their prescribed storage life. It is a known fact that, unlike all other versions of the R11F-300, these two variants were designed for installation in underwing nacelles, differing from the buried versions primarily in having a dorsally mounted accessory gearbox and a longer inlet assembly. These differences vanished in the process of conversion to R11AK standard, which necessitated major changes to many of the engine's components, including the attachment points. The R11AK was interchangeable with the R11K1/R11K2, requiring only minor adaptations of the airframe.

Despite the different design features and the different parameters of the original engine, all versions of the R11K had an identical thrust rating of 2,450 kgp. This was obtained by adjusting the fuel flow and hence engine speed.

Beyond the Great Wall

CK-1 target drone

In the late 1950s the People's Republic of China took delivery of a batch of La-17 target drones. As the stock started running low, the issue was raised of launching indigenous production of similar UAVs by the simple expedient of copying the Soviet design, as had been the case with many Soviet aircraft. The work of reverse-engineering the La-17 commenced in April 1968; an experimental batch of ten was built for test and development purposes. The programme was completed in 1976 and the Chinese version was officially included into the People's Liberation Army Air Force (PLAAF) inventory in March 1977 as the CK-1; CK stood for Chang Kong (Blue Sky).

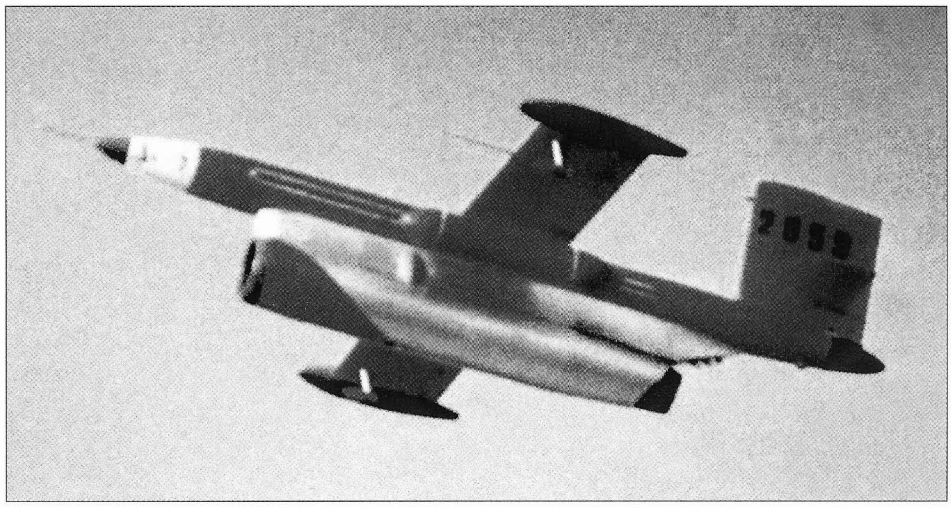
The CK-1 was powered by a WP-6 engine (Wopen-6 – turbojet engine, Model 6), a licence-built version of the RD-9B which powered the J-6 (F-6) fighter – the Chinese version of the MiG-19S – and the locally designed Q-5 (A-5) strike aircraft derived from it. It was not a straight copy of the La-17, being fitted with a locally designed autopilot and featuring changes to the airframe and systems (including the fuel system). The typical flight profiles of the CK-1 also differed appreciably from those of the Soviet forebear.

Like the La-17, the CK-1 utilised a conventional layout with rectangular wings and tail surfaces of simplified design; the horizontal and vertical tail surfaces were interchangeable. The engine was likewise installed in a ventral nacelle. Like the La-17MA and subsequent versions, the CK-1 was ground-launched, making use of rocket boosters, and was controlled either by a programme entered into the autopilot or by radio commands. A major difference was that the Chinese drone utilised a parachute recovery system.

Further development of the CK-1 in China proceeded along completely separate lines as described below.

CK-1A target drone

The first derivative of the CK-1 brought out in 1977 was the CK-1A featuring cylindrical underwing pods housing additional mission equipment.



A Dayglo red CK-1B target drone, showing the underwing fuel tanks and blade aerials.

Basic specifications of the CK-1 target drone

Wing span	7.5 m (24 ft 7⅝ in)
Length overall	8.44 m (27 ft 8⅝ in)
Height	3.00 m (9 ft 10¼ in)
Wing area, m² (sq ft)	8.55 (91.93)
Engine thrust, kgp (lbst)	2,600 (5,730)
Launch weight, kg (lb)	2,450 (5,400)
Maximum speed, km/h (mph)	910 (565)
Range, km (miles)	900 (559)

CK-1B target drone

A new version designated CK-1B entered flight test in May 1982; it was optimised for low-altitude flight and featured non-jettisonable external fuel tanks supplanting the CK-1A's equipment pods. The CK-1B was included into the PLAAF inventory in February 1983.

CK-1C target drone

In May 1983 the Chinese engineers started work on the CK-1C, an enhanced manoeuvrability version capable of simulating modern agile combat aircraft with greater realism. The control system was revised to allow the drone to pull relatively high Gs during evasive manoeuvres. Two prototypes entered flight test in 1984; in March 1985 a CK-1C drone was used as a target for no fewer than five SAMs in a single sortie.

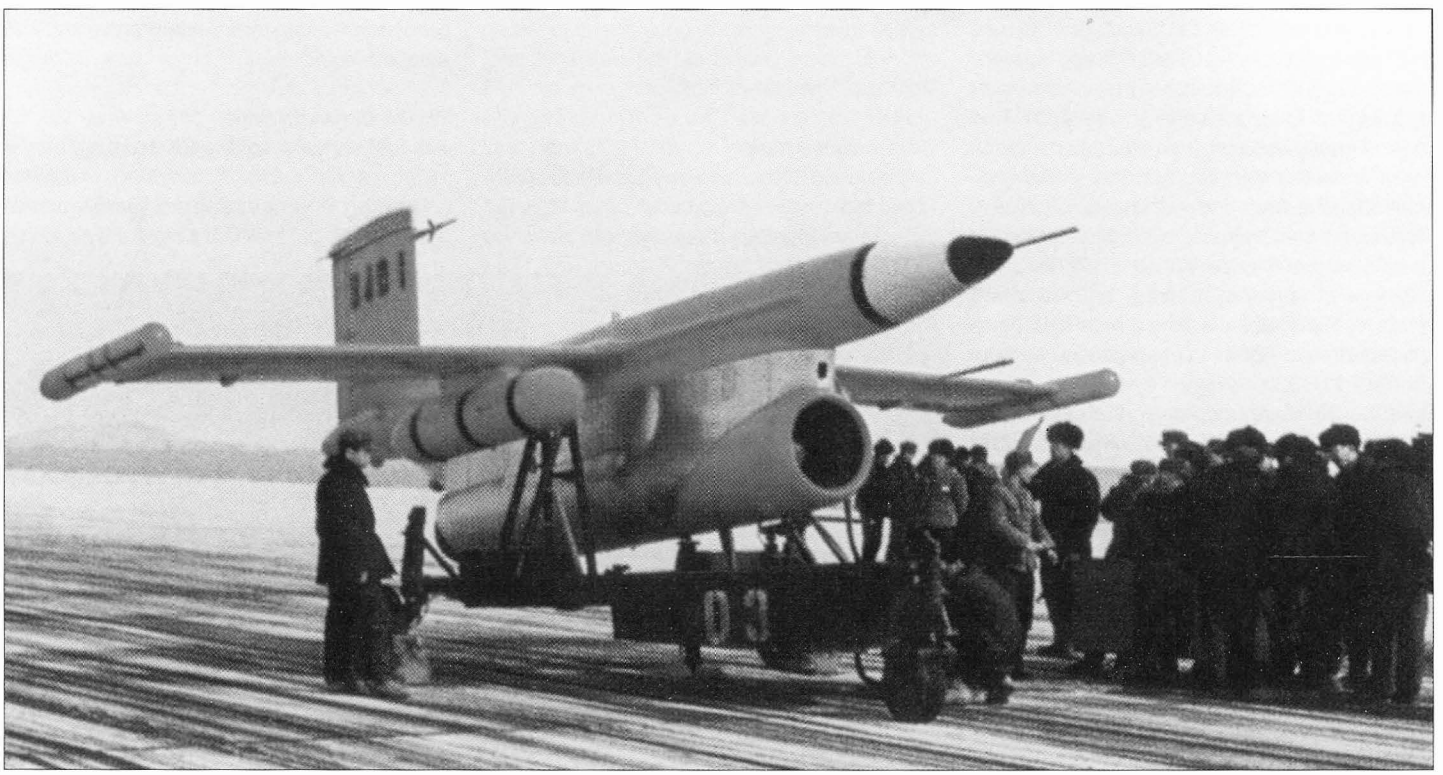
Details of the CK-1C were made available at the MosAeroShow-92 airshow held at Zhukovskiy on 11th-16th August 1992. The drone features two underwing pods with equipment providing an infra-red signature, as well as five angle reflectors, light and smoke tracers. The main fuel tank is supplemented by two external tanks; some other equipment changes are incorporated. The airframe is virtually identical to that of the La-17M and the WP-6 engine is housed in a lengthened nacelle. A ground launcher is used.

As we conclude this chapter, an old Soviet aviation anecdote comes to mind. When Communist Party Central Committee Secretary General and Council of Ministers Chairman Nikita S. Khrushchov first laid eyes on the La-17 while inspecting new aviation hardware, the small propeller on the nose caught his attention. His conclusion was unambiguous: if such a small airscrew can propel such a relatively large aircraft, the machine should be accepted for service by all means.

The La-17 family was widely used for live weapons training and testing new weapons systems in the Soviet Union and other Warsaw Pact nations for many years. The Soviet versions were in production for nearly 30 years and remained in service for more than 40 years. Few aircraft can boast such longevity, and those that can usually enjoy world fame – such as the Polikarpov Po-2 primary trainer/utility aircraft, the Tupolev Tu-16 twinjet medium bomber and Tu-95 four-turboprop strategic bomber, the MiG-15, MiG-17 and MiG-21 tactical fighters, the Douglas DC-3 (which we know by many names), the Boeing B-52 Stratofortress, the British Aerospace (née Hawker Siddeley) Harrier and the Dassault Mirage III. The La-17 'missed out' in this respect – first and foremost because it was a humble drone. Nevertheless, it gained the distinction of being the Lavochkin aircraft that was smallest in size but built in the largest numbers. It was also the last of Lavochkin's post-war aircraft to see production – and the only one of his aircraft to have a long service career. Even though production has long since ended, there are still enough La-17s available to allow operations to continue for a few more years.

True, the La-17 was not the only Soviet target drone in its day; it had the Yak-25RV-II to keep it company. However, being a conversion of the Yak-25RV high-altitude reconnaissance aircraft (*raz**ved**chik vy**sot**nyy*), the Yak-25RV-II was costly and was only used as a high-altitude target, operating at altitudes of 18,000-20,000 m (59,055-65,620 ft) which the La-17 could not reach. Besides, the Yak-25RV-II lacked the advantage of zero-length launch, requiring airfields to take off.

No information on the operational use of the TBR-1 unmanned aerial reconnaissance system have ever been released. What is known, however, is that it has been exported. During the fighting in the Bekaa Valley in 1982 Israel made large-scale use of UAVs – among other things, as a way of forcing the Syrian SAM units to shoot them down and expend their supply of missiles, whereupon the defenceless SAM sites would be wiped out by McDonnell Douglas F-4E Phantom II fighter-bombers. In turn, the Syrians ordered and fielded the TBR-1 system including the La-17RM, which received the export designation UR-1.



A CK-1A serialled 9401 is placed on a ground handling dolly for inspection by Chinese officials. Apart from the underwing equipment pods, it differs from the La-17M in the shape of the wingtip pods (which are cylindrical, not teardrop-shaped) and in lacking the propeller-like generator drive vane in the nose.

Chapter 2

The Pilotless Tupolevs

In 1956 the OKB-156 design bureau headed by the famous aircraft designer Andrey Nikolayevich Tupolev sprouted a new subdivision tasked with developing all manner of UAVs. Soon it received the official appellation 'Section K'; little by little it evolved into a fully-fledged design bureau within OKB-156. The Tupolev OKB's first ventures into this field, however, date back to 1955.

Section K was headed by the Chief Designer's son (and eventual successor) Aleksey Andreyevich Tupolev, a gifted aerodynamicist. The new section attracted a host of young, talented and highly motivated engineers who formed the backbone of the design team. Many of them later rose to eminence in the Tupolev OKB. However, the 'old guard' was not left out either; in particular, the mobile launchers for the Tupolev UAVs were developed by the OKB's weapons team headed by A. V. Nadashkevich. The Chief Designer himself kept a close watch on the activities of the new section and assisted it in every possible way, being well aware that, given the 'missile itch' that afflicted the Soviet Union's political and military leaders, the UAVs and missiles were the only way of saving the OKB's traditional specialisation from being axed. With Khrushchov's disdainful attitude towards manned military aviation, nobody was immune – even Tupolev with all his authority and political clout.

This chapter deals with the unmanned aerial vehicles developed by OKB-156 (subsequently the Tupolev Aviation Scientific & Technical Complex and, still later, the Tupolev Joint-Stock Co.) since 1955 – with the exception of the surface-to-air missiles. (Yes, Tupolev did SAMs, too!)

'113' (Tu-113) cruise missile project

In 1955 the Tupolev OKB began development of a large stand-off air-to-surface missile. Designated '113' (the designation Tu-113 is sometimes used in retrospect), the missile was intended for the Tu-95 strategic bomber. Concurrently OKB-256 under Pavel Vladimirovich Tsybin was working on the RS supersonic parasite aircraft which was likewise to be carried aloft and launched by the Tu-95. It came in manned bomber, manned reconnaissance and cruise missile versions called RS (*reak**tiv**nyy samo**lyot*** – jet aircraft, as simple as that), RSR (*reak**tiv**nyy samo**lyot**-razved**chik*** – jet reconnaissance aircraft) and RSS (*reak**tiv**nyy samo**lyot**-snar**yad*** – jet cruise missile) respectively, and the Tupolev OKB converted a single bomber into the Tu-95N 'mother ship' (*no**sitel'***) for the NM-1 subscale proof-of-concept vehicle. The idea was to create and field a long-range weapons system comprising the Tu-95 delivery vehicle and a cruise missile developed by either Tupolev or Tsybin.

Interestingly, Council of Ministers directive No.867-408 ordering the development of the Tu-95S-30 missile strike weapons system did not appear until much later – specifically, 31st July 1958, followed up on 9th August by GKAT order No.316. These documents specified a range of 3,500-4,000 km (2,173-2,484 miles) and a speed of Mach 2.5-2.7 at 11,000-12,000 m (36,090-39,370 ft) for the missile itself; the weapons system as a whole was to have a combat radius of 8,500-9,000 km (5,280-5,590 miles). (Note: In 1957 MAP lost its ministerial status together with several other ministries and was 'demoted' to the State Committee for Aviation Hardware (GKAT – *Gosoo**dar**stvennyy komi**tet** po aviatsi**on**noy **tekh**nike*) due to Khruschchov's predilection towards missiles. In 1965, however, GKAT regained its original name and 'rank' after Khrushchov had been unseated and replaced by Leonid I. Brezhnev.)

By then OKB-256 was hard at work on the S-30 cruise missile that was considered as the first choice for carriage by the Tu-95S strike aircraft. However, the Tupolev OKB believed that, with a little luck, their own product – the '100' or '113' missile – might yet be selected.

The '113' reached the advanced development project (ADP) stage in May 1955. It was a rather unconventional-looking machine. Two Solov'yov D-20 or Klimov VK-11 afterburning turbofans were installed in cylindrical nacelles at the tips of the mid-set swept wings with a low aspect ratio of 1.53; the use of ramjet engines was also considered. All of the equipment and most of the fuel were housed in the fuselage; the latter had a length of 23 m (75 ft 5½ in) and a diameter of 1.54 m (5 ft 0⅝ in), which equals an unusually high fineness ratio of 14.9. The forward fuselage with an internal volume of 550 litres (121 Imp gal) accommodated the guidance system. Further aft, in the centre fuselage section, were the No.1 fuel tank holding 5,000 kg (11,020 lb) of kerosene, a heat-insulated bay for the nuclear warhead and the Nos 2, 4 and 5 tanks holding 3,680 kg (8,110 lb), 4,420 kg (9,740 lb) and 3,500 kg (7,720 lb) of fuel respectively. The rear fuselage section housed the No.6 fuel tank holding 500 kg (1,100 lb) of fuel, with a control system bay above it. A long conduit housing control runs ran along the fuselage underside. The thin wings with 60° leading-edge sweep incorporated the Nos 3 integral tanks holding 700-900 kg (1,540-1,980 lb) of fuel and featured relatively large ailerons. The tail unit was of the conventional type with inset rudder and elevators.

Development of the stand-off missiles (curiously, referred to in the documents of the day as *podves**noy** samo**lyot*** – 'suspended', that is, captive or parasite aircraft) at the Tupolev and Tsybin bureaux continued apace until 5th February 1960. That day the Council of Ministers issued directive No.138-48 calling all work on the Tu-95S-30 system to be suspended (no pun intended).

Basic specifications of the '113' missile (as per ADP documents)

Length overall	23 m (75 ft 5½ in)
Wing span	8.0 m (26 ft 2³⁄₃₂ in)
Wing area, m² (sq ft)	42.0 (451.6)
Launch weight, kg (lb)	30,700 (67,680)
Empty weight, kg (lb)	9,000 (19,840)
Fuel load, kg (lb)	18,000 (39,680)
Warhead weight, kg (lb)	3,700 (81,570)
Missile rack weight, kg (lb)	200 (440)

'121' (Tu-121) strategic cruise missile project (*izdeliye* S)

Section K's activities included development of a whole series of pilotless aircraft projects intended for various missions. These UAVs were designed to cruise at around Mach 2.5, covering a distance of 3,000-3,500 km (1,863-2,173 miles).

The first of these projects was a strategic cruise missile provisionally designated *izdeliye* S; the S stood for ***sred**niy [samo**lyot**-*

snaryad] – medium cruise missile. This weapon was designed for the same mission as the intercontinental ***Boo**rya* (Storm) and *Bu**ran*** (Blizzard) cruise missiles developed by Lavochkin's OKB-301 and Vladimir M. Myasishchev's OKB-23 respectively but had only half the range.

For the first time in its history the Tupolev OKB was facing the task of creating not just a missile with a high supersonic cruising speed but also the complete ground support systems – the launcher and other associated equipment used for pre-launch preparations, as well as the test and support equipment maintaining the missile in operational condition. This was a monstrous task that rivalled the creation of intercontinental ballistic missiles (ICBMs) and SLVs in its complexity.

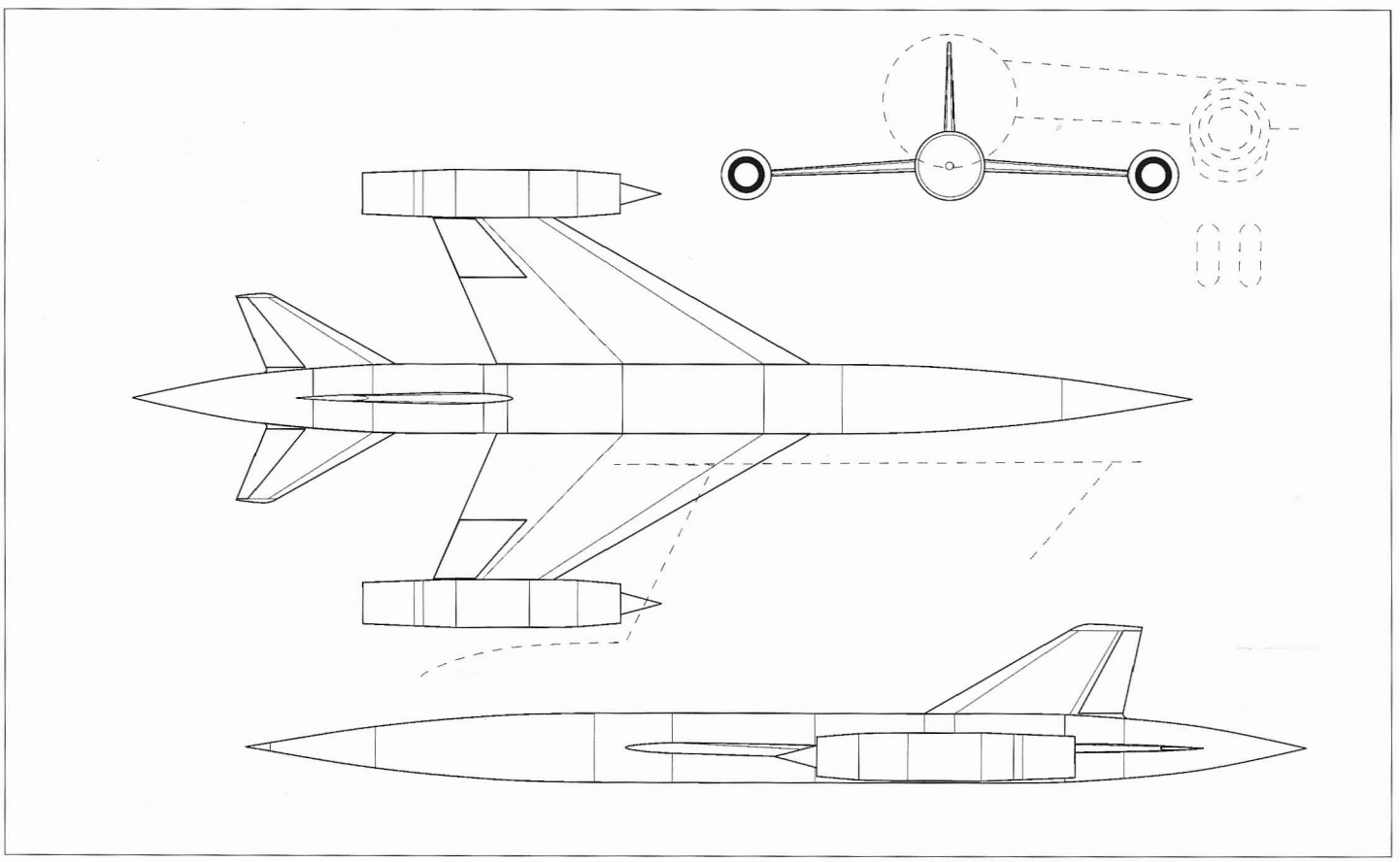
Development of the *izdeliye* S cruise missile was officially commissioned on 23rd September 1957 when the Council of Ministers let loose with directive No.1145-519, followed on 10th October by GKAT order No.343. Both documents tasked OKB-156 with designing and building a prototype of the *izdeliye* S; at the OKB the missile received the designation '121' (or Tu-121).

At that point the OKB had already undertaken quite a large amount of research and development work on the subject – which was just as well, for the development and production entry deadlines set by the government were extremely tight. The development effort involved a large number of manufacturing enterprises and research establishments nationwide, with OKB-156 exercising overall control and holding overall responsibility for the programme.

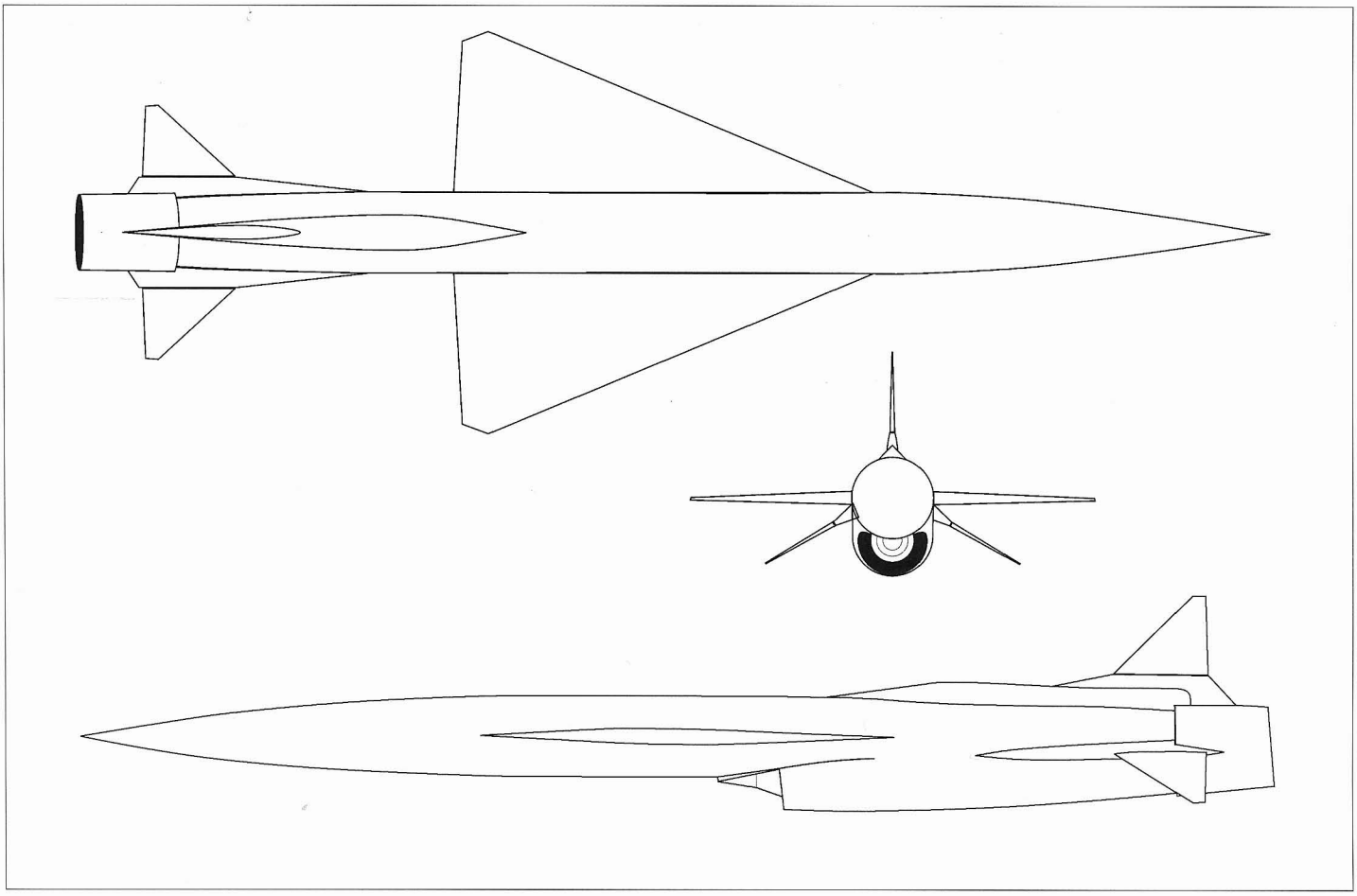
Starting in the fourth quarter of 1958, the Tupolev OKB was to manufacture nine examples of the *izdeliye* S ('121') within a six-month period; the first of five flying prototypes was to commence ground and flight tests in the fourth quarter of 1958. Meanwhile, the Novo-Kramatorsk Machinery Plant was to manufacture two sets of launch ramps and transporter/loader vehicles (TLVs) to Tupolev OKB specifications by October 1958, using manufacturing documents supplied by the OKB. These were to be used in the flight tests of the '121' missile prototypes. By way of assistance in completing this priority programme, the flight test facility of the recently dissolved OKB-23 at Zhukovskiy was transferred lock, stock and barrel to the Tupolev OKB. Later, a pre-production batch of 25 *izdeliye* S missiles was to be manufactured by one of GKAT's series production plants before the end of 1959 with a view to widening the scope of the test work.

The *izdeliye* S was to be powered by a specially developed expendable turbojet delivering an impressive 15,000 kgp (33,070 lbst). The Klimov VK-9 was envisaged originally, but this engine was rated at 'only' 10,000 kgp (22,045 lbst) and turned out to be stillborn. Hence the development effort was concentrated entirely on the massive KR15-300 turbojet brought out by Sergey Konstantinovich Tumanskiy's OKB-300. Interestingly, the KR15-300 reversed the usual trend, being not a remanufactured version of a time-expired 'normal' fighter engine but a 'clean sheet of paper' design that later evolved into a 'normal' fighter engine – the R15B-300 which powered first a series of Mikoyan heavy interceptor prototypes (the Ye-150/Ye-152 series) and then the production MiG-25. The KR15-300 underwent initial flight tests in subsonic mode on one of the nine Tu-16LL engine testbeds operated by LII. Another Tu-16 was converted into an avionics testbed for verifying the telemetry (data link) system to be fitted to the '121' prototypes. The work on the Tu-16 testbeds was assigned to the Tupolev OKB's branch office in the township of Tomilino a short way south of Moscow.

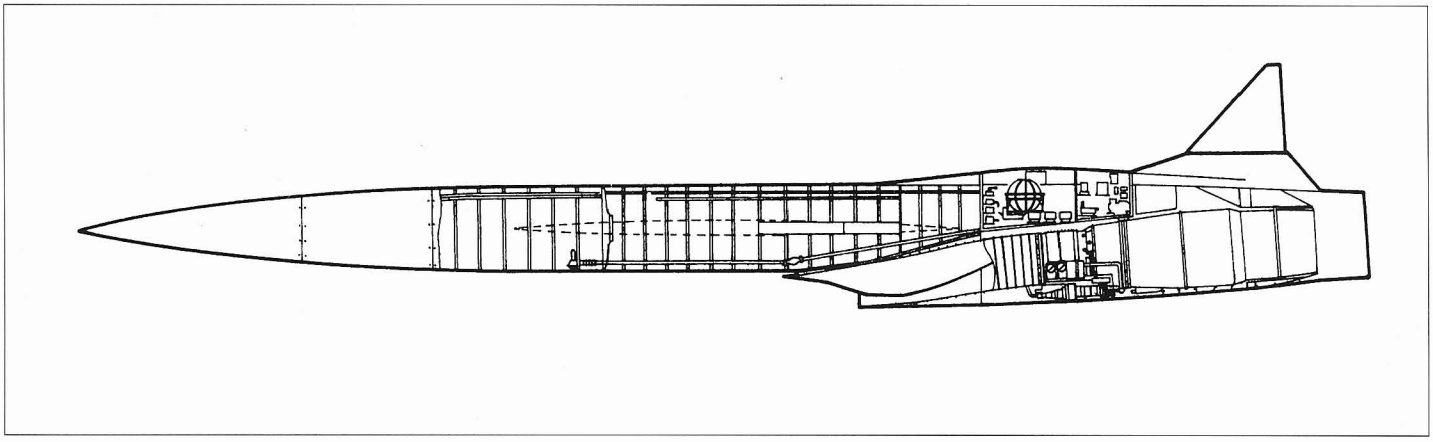
Meanwhile, the Ministry of Medium Machinery (MSM – *Mini**ster**stvo **sred**nevo ma**shin**ostro**yen**iya*) responsible for the Soviet nuclear programme was tasked with developing a compact nuclear warhead for the *izdeliye* S ('121') missile. (This ministry's curious name designed to confuse outsiders was coined by analogy with the Ministry of Heavy Machinery (*Mini**ster**stvo*



A three-view of the projected '113' (Tu-113) cruise missile which was to be carried by the Tu-95. The large ailerons are noteworthy.



Above: A provisional three-view drawing of the '121' (Tu-121) cruise missile.
Below: A cutaway drawing of the '121' cruise missile. Note the shape of the air intake's half-cone.



*tya**zhol**ovo ma**shin**ostro**yen**iya*), whose domain was heavy industries, and the Ministry of Light Industry (*Mini**ster**stvo **lyoh**koy pro**mysh**lennosti*) responsible for textiles and footwear.)

The missile was to feature an autonomous control system automatically guiding it along a pre-programmed route to the target, with astro-inertial course correction en route. This was an adaptation of the *Zem**lya*** (Earth) system developed by FNII-1 (*fili**ahl** na**ooch**no-is**sled**ovatel'skovo insti**toot**a*), a branch of GKAT's NII-1 research institute specialising in aircraft systems, for the abovementioned Boorya and Buran missiles. Since the '121' was to cruise at speeds and altitudes at which kinetic heating would affect airframe and systems alike, the specialised OKB-124 set to work on a cooling system serving the missile's avionics and warhead bays. OKB-140 developed the custom-made GSR-ST-105/18 starter-generator with a self-contained cooling system enabling normal operation at ambient temperatures right up to 400°C (752°F). Hydraulic control surface actuators operated by the autopilot and capable of withstanding high temperatures were created. An especially tough conundrum which the Tupolev OKB had to solve was how to develop a highly efficient air intake allowing the engine to operate normally in all flight modes from launch to supersonic cruise.

As already mentioned, a telemetry system with onboard and ground components was created. An instrumented track was prepared along which the missile would fly during test flights.

The Tupolev OKB's experimental shop completed the first *izdeliye* S ('121') prototypes in the second half of 1958. In the summer of 1959 the prototype missiles were delivered to the Artillery Systems Test &

Basic specifications of the '121' (Tu-121) cruise missile

Length overall	24.77 m (81 ft 3¹³⁄₆₄ in)
Height (fuselage axis level)	4.614 m (15 ft 1²¹⁄₃₂ in)
Wing span	8.4 m (27 ft 6⁴⁵⁄₆₄ in)
Fuselage diameter	1.7 m (5 ft 6¹⁵⁄₁₆ in)
Launch weight, kg (lb)	about 35,000 (77,160)
Cruising speed, km/h (mph)	2,775 (1,723)
Maximum range in a 40 km/h (80-kt) headwind, km (miles)	3,880 (2,410)
Endurance	1 hour 38 minutes
Flight altitude at the beginning of cruise flight, m (ft)	19,900 (65,290)
Flight altitude above the target, m (ft)	24,100 (79,070)

research Range (NIPAV – *Na**ooch**no-is**sle**dovatel'skiy poli**gon** artille**reey**skovo vo'orooz**heni**ya*) in Faustovo near Moscow. Ground checks and adjustments continued until late August. Finally, at 6am on 25th August, just as the Kremlin chimes struck and the Soviet national anthem was broadcast on the radio (a daily routine at 6am and at midnight, it was), the first prototype '121' missile blasted off the ramp, with the entire management of OKB-156 watching anxiously.

The first flight went well; so did some of the ensuing test flights, while a few ended in crashes and the loss of the aircraft. But then, unexpectedly, the government pulled the plug on the programme; Council of Ministers directive No.138-48 dated 5th February 1960 ordered all work on the *izdeliye* S to be stopped. This was through no fault of the missile or the Tupolev OKB. The reason was that the government had placed its bets on intermediate-range ballistic missiles (IRBMs) – specifically, the 8K51 weapons system based on the R-5 missile, the 8K61 weapons system based on the R-12 missile and the 8K63 weapons system based on the R-14 missile – as the Soviet Union's medium-range strategic strike assets. The time for ground-launched cruise missiles had not yet come.

Yet the effort was not in vain. The '121' missile evolved into a supersonic pilotless reconnaissance aircraft forming the core of the Yastreb tactical reconnaissance system. Moreover, it left its mark in Soviet/Russian aviation history as one of the first fixed-wing UAVs to exceed 2,500 km/h (1,552 mph) and break the heat barrier.

The '121' in detail

Type: Supersonic ground-launched cruise missile. The all-metal airframe structure is made of heat-resistant alloys.

Fuselage: Semi-monocoque stressed-skin structure with a high fineness ratio. The fuselage cross-section changes from circular (in the forward fuselage) to elliptical with the longer axis vertical (in the area of the air intake) and back to circular, but of bigger diameter (in the rear fuselage).

The pointed *forward fuselage* includes the nuclear warhead bay, an avionics/equipment bay and a cooling system for both. A recessed astrodome housing a star tracker is provided if an astro-inertial navigation/course correction system is fitted. The *centre portion* of the rear fuselage is occupied by fuel tanks; it incorporates the air intake and wing attachment fittings. The *rear fuselage* incorporates the engine bay and the tail unit attachment fittings.

Wings: Cantilever mid-wing monoplane with delta wings. Leading-edge sweep 67°, slight anhedral from roots. The wings lack control surfaces, all control being exercised by the tail surfaces.

Tail unit: Cantilever tail surfaces of delta planform positioned at 120° with respect to each other. Both vertical and horizontal tail surfaces are all-movable; the fin serves for directional control, while the slab stabilisers (stabilators) are deflected together for pitch control or differentially for roll control. All three tail surfaces are mounted on raised fairings housing the electrohydraulic actuators and their cooling systems.

Powerplant: One Tumanskiy KR15-300 disposable afterburning turbojet rated at 10,000 kgp (22,045 lbst) in minimum afterburner and 15,000 kgp (33,070 lbst) in full afterburner. The minimum afterburner mode is used for cruise flight; the full afterburner take-off rating has a three-minute limit.

The KR15-300 (also called R15K-300) is a single-shaft axial-flow turbojet with an air intake assembly featuring a fixed spinner with 26 radial struts, a five-stage axial compressor, a can-annular combustion chamber, a single-stage turbine, an afterburner and a fixed-area nozzle with an ejector ring attached to the rear fuselage to increase thrust. Engine accessories are driven via a ventral accessory gearbox whose power take-off shaft is located aft of the compressor.

Engine pressure ratio (EPR) 4.75; mass flow at take-off rating 144 kg/sec (317 lb/sec), turbine temperature at T/O rating 1,230°K. Specific fuel consumption (SFC) in full afterburner 2.45 kg/kgp·h (lb/lbst·h). The designated service life is 50 hours.

The engine breathes through a ventral semi-circular supersonic air intake with a fixed perforated centrebody (half-cone) optimising the airflow throughout the flight envelope. The upper lip is set apart from the fuselage underside, acting as a boundary layer splitter plate. In launch mode the air intake is partly covered by a semi-annular airflow guide used at subsonic speeds; it is jettisoned when the missile exceeds Mach 1.

Two PRD-52 solid-fuel rocket boosters with outward-canted nozzles delivering an impulse of 75,000 kgp (165,340 lbst) are attached to faired fittings on the lower centre fuselage sides and the wing undersurface for take-off; they are positioned so that their thrust vectors pass through the missile's centre of gravity. They serve a dual purpose, as the missile literally sits on them while on the launch ramp (that is, its weight is transferred to the ramp via the boosters' bodies). The boosters are jettisoned five after take-off after accelerating the missile past Mach 1.

'123' strategic cruise missile project (first use of designation; *izdeliye* D)

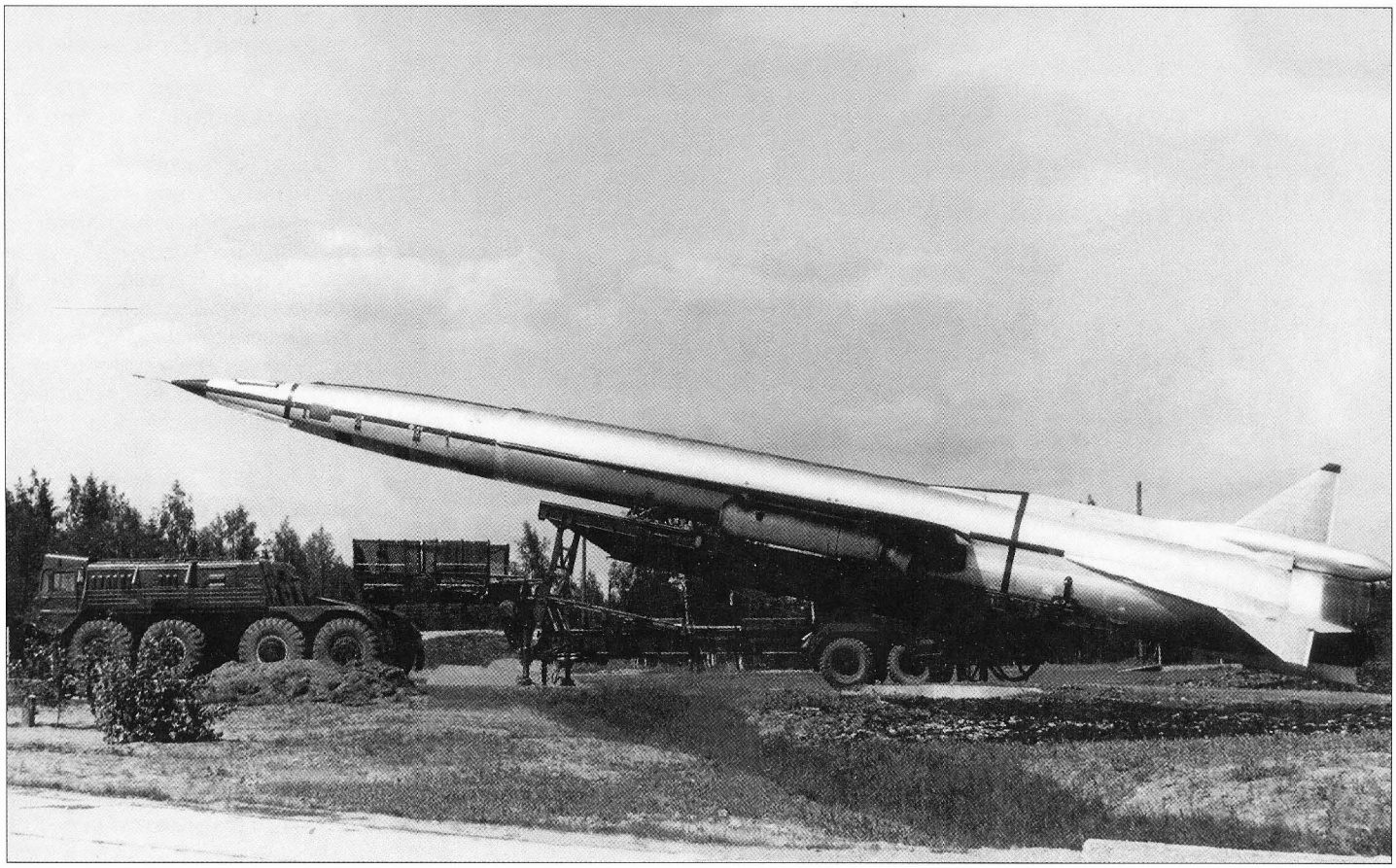
The '121' missile (*izdeliye* S) soon became the basis for a new cruise missile project designated '123' (*izdeliye* D). It differed from the original model mainly in having longer range (hence the D may stand for ***dahl'niy*** – long-range) and a more powerful nuclear warhead.

To extend its range the '123' was re-engined with an NK-6 afterburning turbofan developed by Nikolay D. Kuznetsov's OKB-276; at 22,000 kgp (48,500 lbst), it was not only considerably more powerful than the KR15-300 turbojet but also more fuel-efficient in cruise flight. The missile was slightly larger than the '121' and featured a greater fuel capacity which, together with the new powerplant, was expected to give it intercontinental reach. An astro-inertial navigation system was provided.

The '123' missile progressed no further than the ADP stage. Later this designation was reused for a reconnaissance drone.

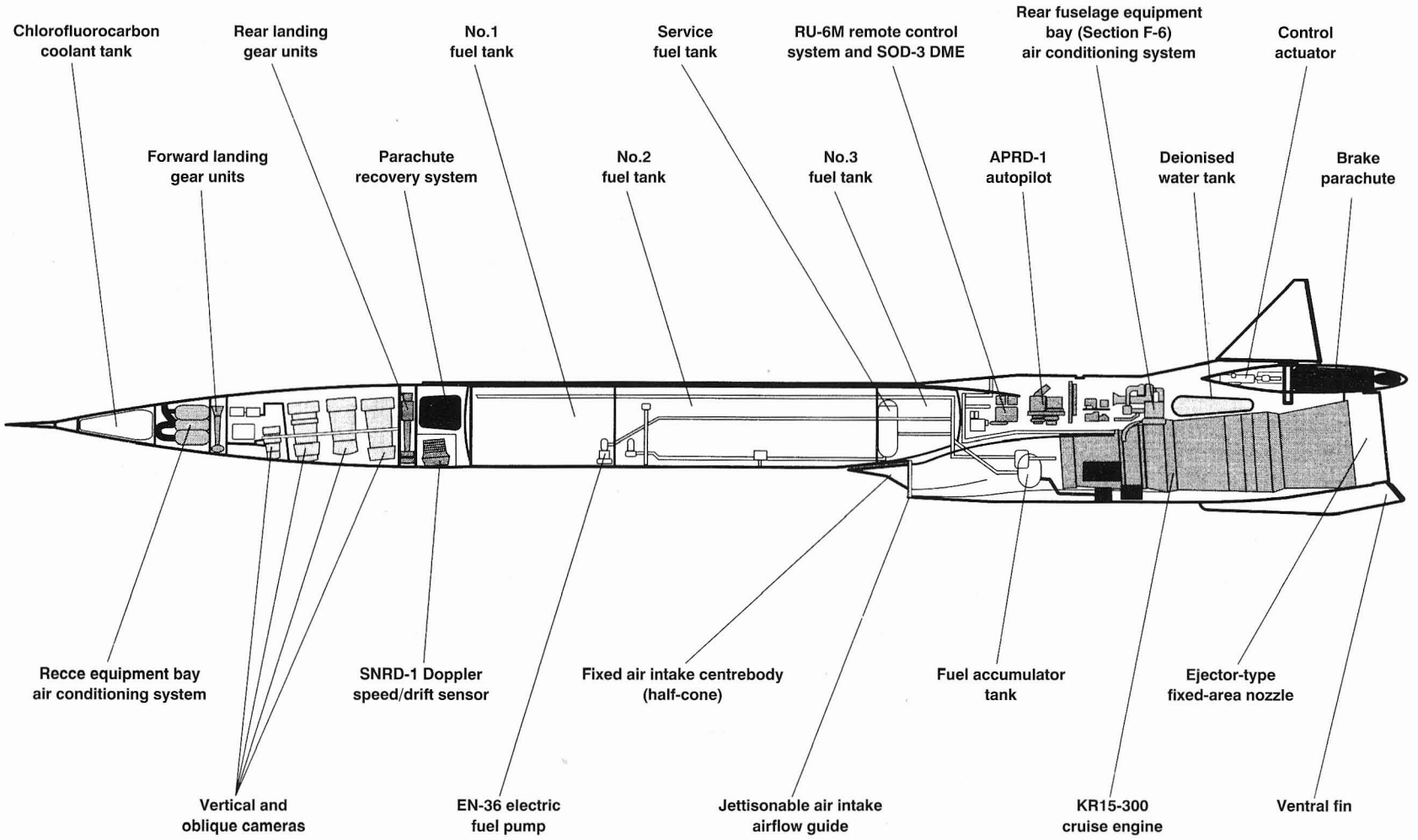
'133' strategic cruise missile project (*izdeliye* SD)

In an attempt to turn the existing '121' missile into an intercontinental weapon with a range of 5,000-6,000 km (3,105-3,726 miles) at the expense of minimum design changes, the Tupolev OKB envisioned a version designated '133' (*izdeliye* SD – that is, *izdeliye* S, ***dahl'**-neye*). It differed from the original model in having extra fuel tanks, including drop tanks. The '133' fared even worse than the previous project, being abandoned at the preliminary design stage.



Above: One of the '123' (Tu-123) reconnaissance drones at a GK NII VVS test range on the SARD-1 (STA-1) transporter/launcher vehicle consisting of a MAZ-537V tractor unit (disengaged before launch) and a special SURD-1 (ST-30) semitrailer. Note the red photo calibration markings on the fuselage.

This view illustrates clearly the enormous size of the '123'; consider that the MAZ-537 is no small vehicle either. The PRD-52 rocket boosters are clearly visible.



A cutaway drawing of the '123' reconnaissance drone.

DBR-1 (Yastreb-1) long-range unmanned aerial recce system:

'123' (Tu-123) long-range recce drone (second use of designation)

Despite the termination of the *izdeliye* S ('121') missile programme, the Tupolev OKB persevered with supersonic unmanned aerial vehicles. On 16th August 1960, six months after killing the *izdeliye* S, the Council of Ministers issued directive No.900-376, followed ten days later by the appropriate GKAT order, to the effect that OKB-156 was to commence development of the ***Yas**treb* (Hawk) long-range unmanned photo/electronic reconnaissance system.

The system was to be built around a UAV sharing the airframe and powerplant of the '121' cruise missile. It was to be fitted out with photo reconnaissance (PHOTINT) and electronic intelligence (ELINT) equipment, a data recording/storage system and a system allowing the intelligence gathered to be delivered to the required spot for collection. A separate item in the documents instructed OKB-156 to consider the possibility of making the aircraft re-usable. Manufacturer's flight tests were to commence in the third quarter of 1960 (that is, barely a month or two after the CofM directive!), the state acceptance trials (to be held jointly by the OKB and the Air Force) being scheduled to begin a year later. At the OKB the aircraft received the designation '123' (Tu-123) which had earlier been assigned to a related but stillborn design.

The directive also specified the production plant that was to build the reconnaissance drone; it was plant No.64 in Voronezh, which was then busy mastering another Tupolev product, the Tu-128 heavy interceptor. (Thus, oddly, a lower model designation was allocated to an aircraft which appeared after the Tu-128.) Pursuant to the directive a development batch of 22 – four prototypes built by the OKB's experimental plant, MMZ No.156 'Opyt' (MMZ = *Mos**kov**skiy ma**shin**ostroi**te**l'nyy za**vod*** – Moscow Machinery Plant; the name translates as either 'experiment' or 'experience') and 18 pre-production Voronezh-built examples – was to be manufactured in 1960 and 1961 respectively.

In addition to the design problems common to the missile and reconnaissance versions (that is, the '121' and the '123'), the Tupolev OKB had to tackle a number of issues which were unique to unmanned aerial reconnaissance systems. Specifically, there was the need to:

• ensure autonomous operation away from established maintenance bases and the ability to operated from unprepared pads lacking stationary ground support equipment;

• ensure the ability to redeploy over distances of up to 500 km (310 miles) without resorting to other means of transportation while retaining the system's operational capability;

• incorporate a jettisonable (recoverable) nose section or capsule housing the mission equipment and fitted with a parachute/retrorocket recovery system ensuring a smooth touchdown on land or water for retrieval;

• include intelligence data processing equipment into the system;

• develop specialised automatic test equipment for checking the operation of the aircraft's systems;

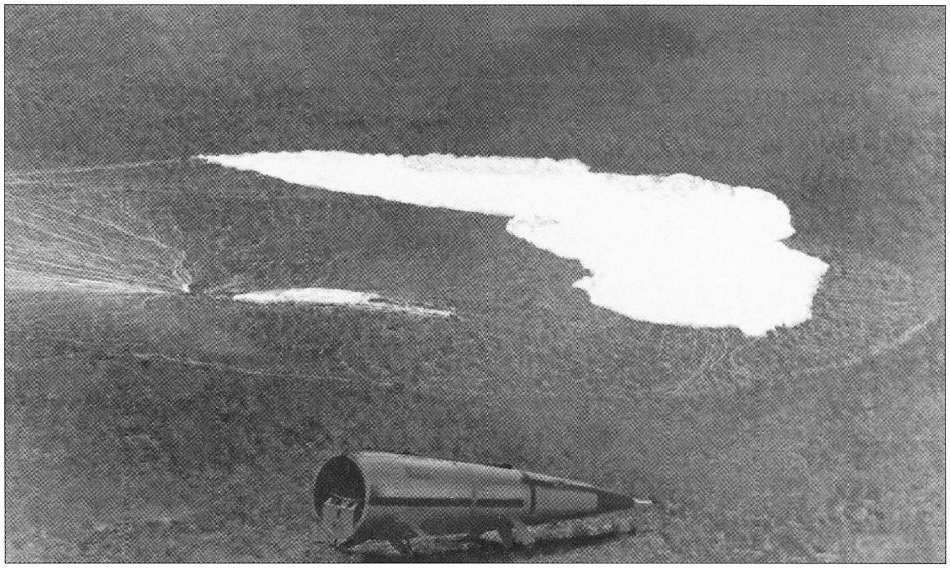
• protect the navigation system avionics, the precision mission equipment (especially the camera lenses and the ELINT systems' frequency generators, which were very vulnerable to overheating), the DC generators and some control system and fuel system components against the strong kinetic heating in cruise flight;

• develop an environmental control system capable of maintaining the required temperature, pressure and air humidity in the avionics/mission equipment bays with a higher degree of precision than the ECS of the '121' missile;

• create a new precision navigation suite comprising an automatic flight control system (AFCS) enabling autonomous flight along a predesignated route and a compass system guiding the aircraft to the designated area where the reconnaissance equipment capsule is to be jettisoned and retrieved;

• develop a long-range operations (LOROP) camera with a focal length of 1,000 mm (39⅜ in) producing pictures making it possible to define such objects as railway tracks, trains and locomotives, small buildings and single vehicles (tanks, armoured personnel carriers and automobiles);

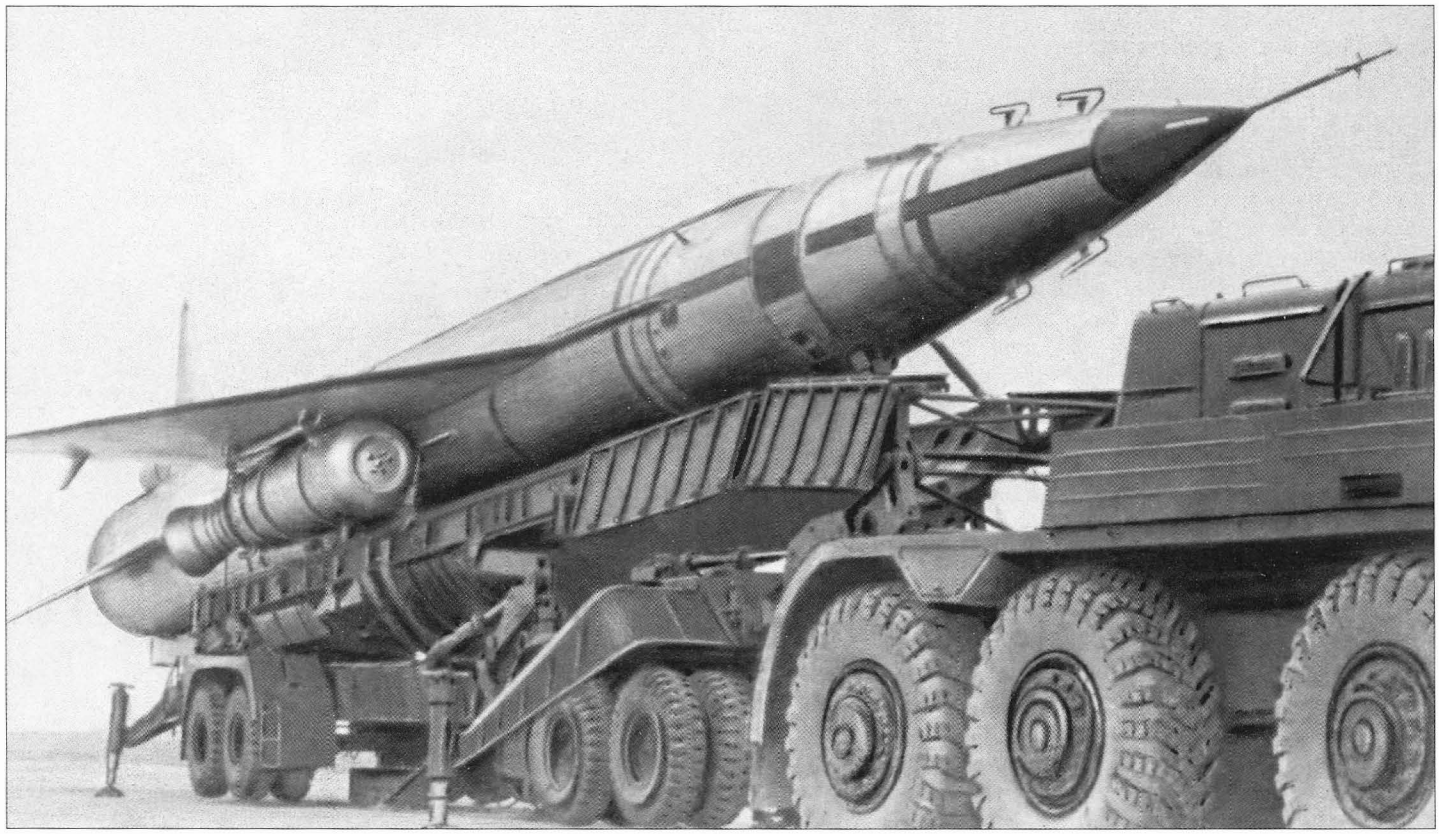
• develop and verify an operational ideology for all stages of the system's operation and issue operating manuals for the system as a whole and its components for use by the first-line units.



The recoverable nose section of a '123' after landing; the detached parachute lies beyond it. Standing on its four short landing gear struts, the thing has a surreal look – 'an anteater from outer space'.

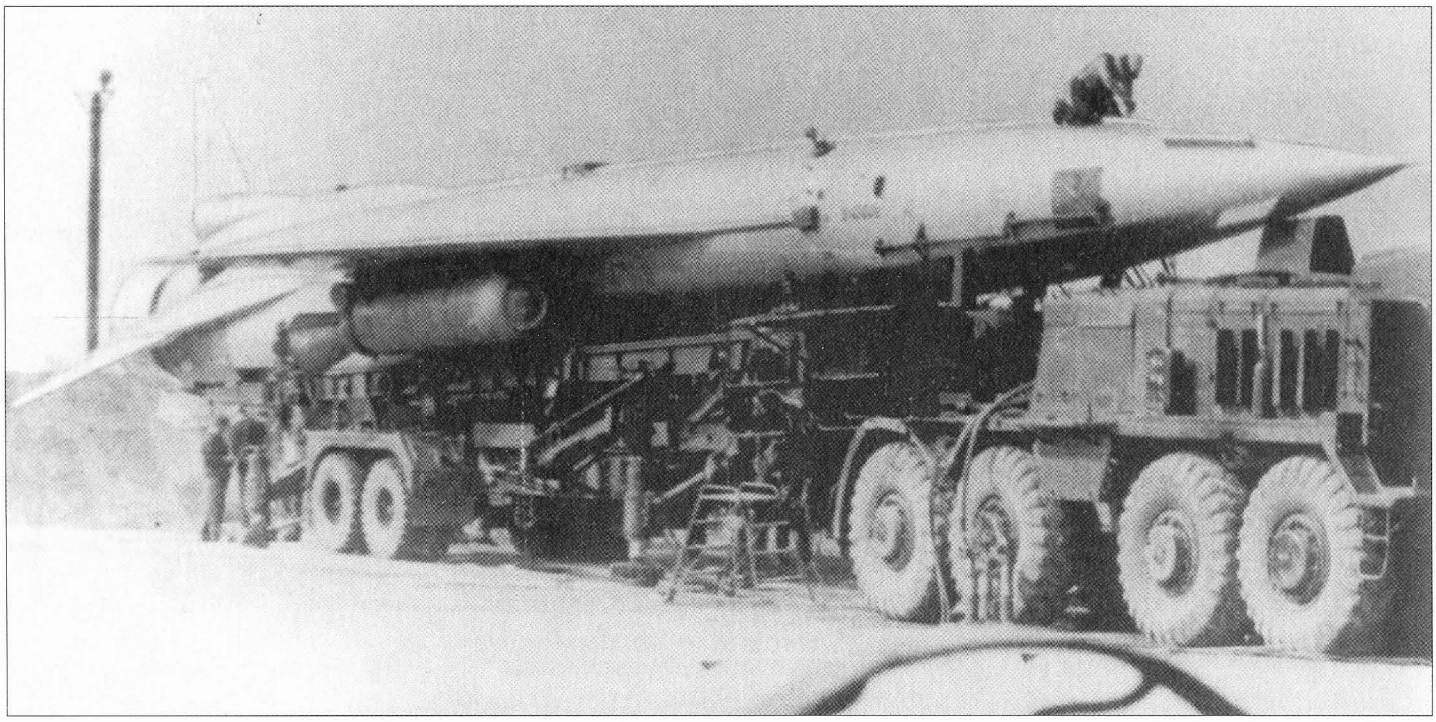
Section K chief Aleksey A. Tupolev exercised overall supervision of the '123' programme. Many other talented designers were also involved; thus, Valentin I. Bliznyuk was the system's project chief and defined the aircraft's technical outlook, while V. P. Sakharov supervised the design work. V. P. Nikolayev was in charge of prototype manufacturing at MMZ No.156, while the preparations for the tests and the test programme proper were the domain of the section headed by B. N. Grozdov. As had been the case with the '121' missile, development of the reconnaissance drone's self-propelled launcher and the preparations for its series production were the responsibility of A. V. Nadashkevich.

The scope of the design work performed and the flight test experience accumulated with the '121' cruise missile made it possible to build the prototypes of the '123' reconnaissance drone and prepare them for testing very quickly indeed. The manufacturer's flight tests and the joint state acceptance trials of the Yastreb-1 system (alias DBR-1, that is, ***dahl**'niy bespi**lot**nyy raz**ved**chik*** – long-range unmanned reconnaissance aircraft) proceeded right on schedule. The manufacturer's tests were completed in September 1961, involving the four Moscow-built prototypes. The state acceptance trials commenced in the same month and lasted until December 1963. Stage A (the so-called General Designer's stage, meaning that the OKB was actively involved) was performed on six pre-production machines bearing the product code *izdeliye* 123A; Stage B performed mostly by the military involved another five examples which were accordingly known as *izdeliye* 123B.



Above: This '123' has two pairs of L-shaped loop aerials associated with the telemetry system mounted on the detachable forward fuselage. Note that the TLV is different from the one depicted on page 31 and below, featuring a four-axle 16-wheel trailer.

Another view of the two impressive vehicles, with the '123' in launch position; the camera ports are clearly visible. Note how the red stripe on the fuselage extends along the wing leading edges. Note also the three headlights characteristic of the MAZ-537V; the later MAZ-537G lacks the centre headlight.

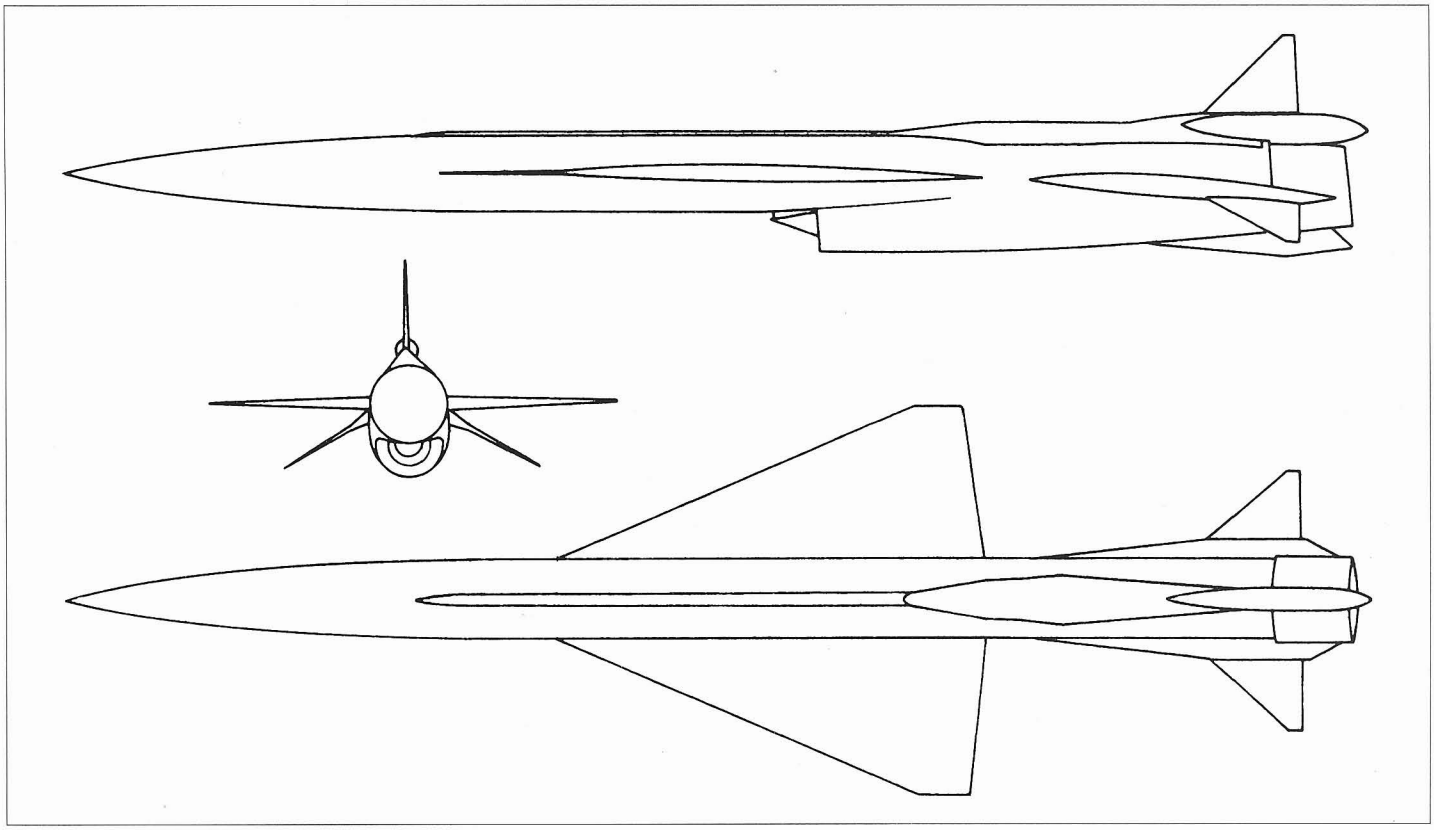


Above: A production Batch 10 Tu-123 built in 1965 (c/n 5401006) on the TLV after reassembly for launch; the launch ramp is still horizontal. Note the concrete blast shield aft of the vehicle.

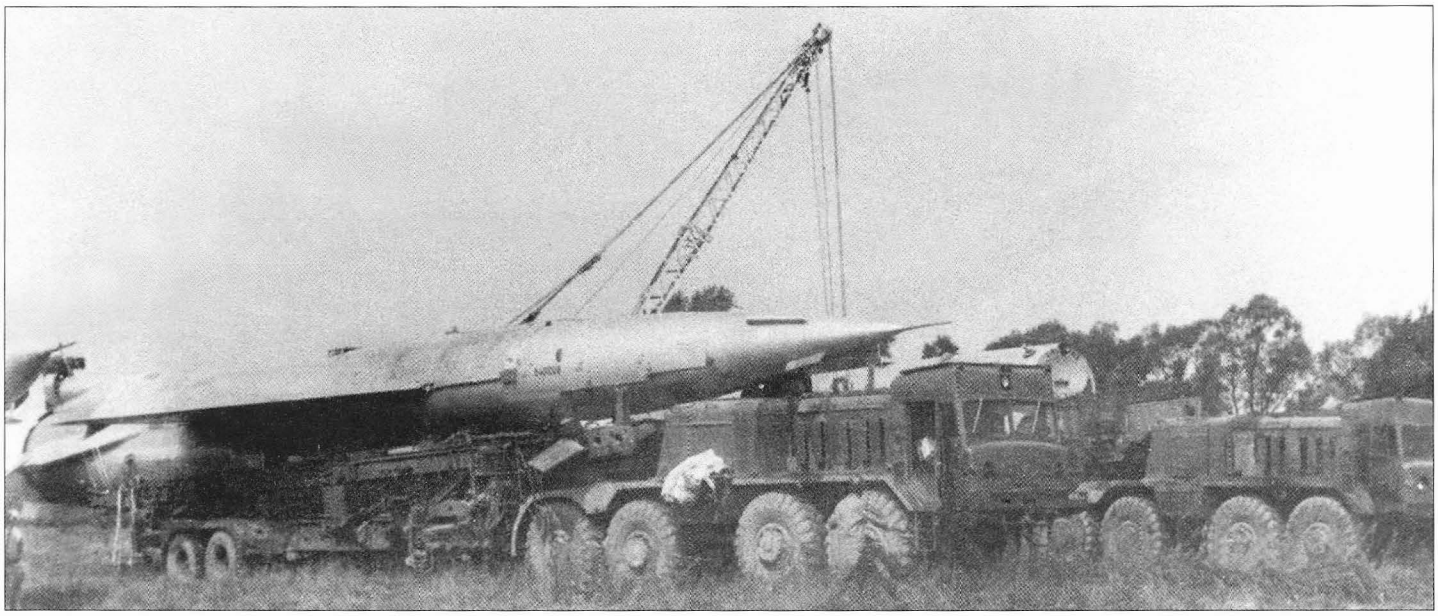
Upon completion of the trials a report was endorsed by the heads of the various ministries and organisations responsible for the development of the DBR-1 (Yastreb-1) long-range unmanned aerial reconnaissance system; its concluding part said that the system was recommended for service. The recommendation became a fact on 23rd May 1964 when the Council of Ministers issued directive No.444-178 to this effect.

The '123' (Tu-123) pilotless reconnaissance aircraft was mass-produced at the Voronezh aircraft factory, as was part of the associated support equipment. The remainder of the ground support equipment was manufactured by the Novo-Kramatorsk Machinery Plant (the launch ramp) and several plants in Kursk, Khar'kov and Tyumen' assigned to various ministries.

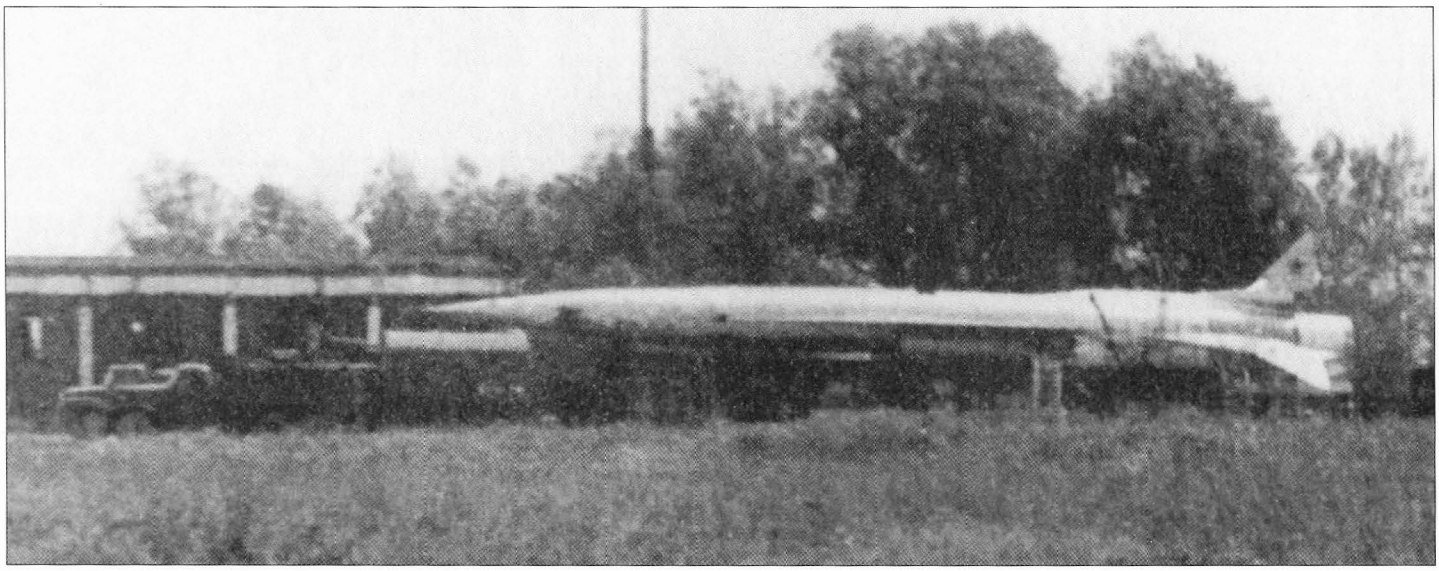
The DBR-1 aerial reconnaissance system is designed for PHOTINT and ELINT of enemy



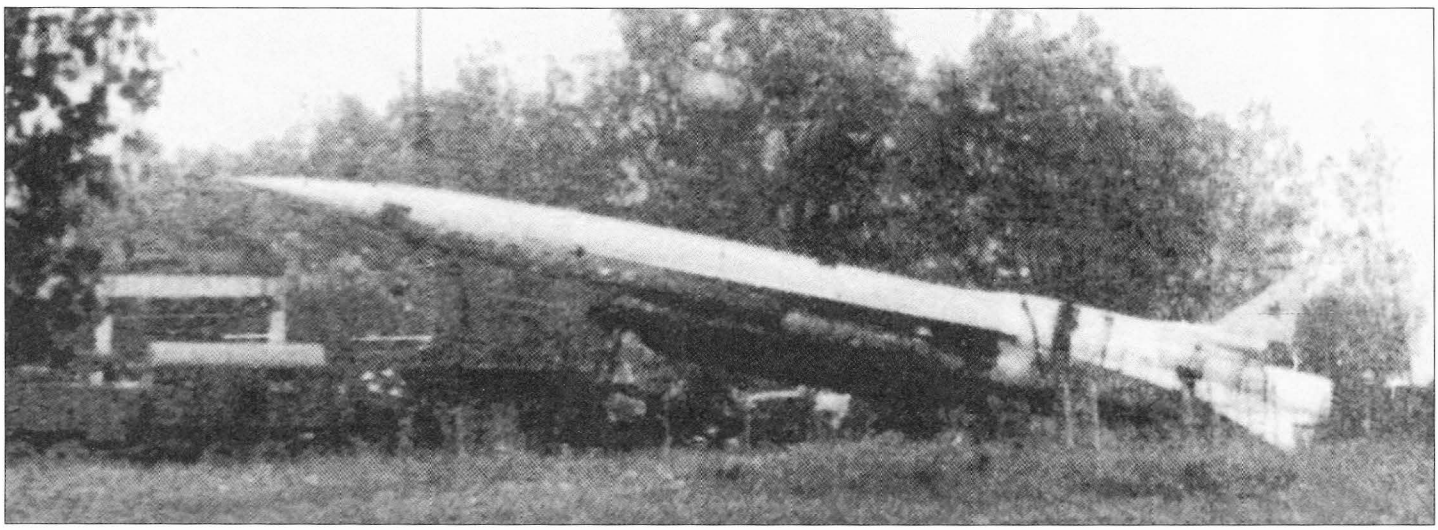
A three-view of the '123' (Tu-123) reconnaissance drone.



Above: An SARD-1 TLV with Tu-123 c/n 5401006 sandwiched between two further examples. The drone is already complete, except for the rocket boosters which have yet to be fitted; the one in the background is in the process of reassembly (note the mobile crane) and the forward fuselage is still missing.



Above: a Tu-123 on the launch ramp. Unlike the prototypes, production examples were silver overall and carried the Soviet Air Force star insignia.



Another view of the same drone poised for launch; the MAZ-537 tractor unit is disengaged and moved away to safety.

missile sites, airfields, naval bases and seaports, defence industry facilities, troop concentrations, naval task forces and aircraft carrier groups, and air defence and anti-missile defence systems. It is also used for assessing the aftermath of attacks with nuclear, biological and chemical (NBC) weapons. PHOTINT is performed by photographing long strips of terrain or large areas with general-purpose and detail reconnaissance cameras. ELINT involves capturing and recording the signals of the enemy's radio and radar transmitters active in the area, which allows their type and location to be determined.

The system comprised the following components:

• the '123' (Tu-123) reconnaissance drone and its PHOTINT and ELINT equipment;

• a set of mobile ground support equipment enabling mission preparation, launch, return to a designated area upon completion of the objective, recovery of the reconnaissance equipment capsule and prompt delivery of the contents to intelligence deciphering stations.

The system was highly mobile and suited for autonomous operation from ad hoc field launch pads, which rendered it less vulnerable to enemy air raids and missile strikes. It enabled daytime general-purpose and detail PHOTINT and round-the-clock general-purpose ELINT of the enemy's operating areas adjacent to the frontlines. The aircraft could photograph a strip of terrain 60-80 km (37.2-49.6 miles) wide and 2,700 km (1,677 miles) long to 1/100,000th scale or a 40 x 1,400 km (24.8 x 869 miles) strip to 1/20,000th scale. ELINT in side-looking mode was possible to a maximum depth of 390 km (242 miles) from the aircraft's track. The recoverable nose section housing the reconnaissance equipment could be reused multiple times.

The DBR-1 (Yastreb-1) was the Soviet Union's first supersonic unmanned aerial reconnaissance system capable of fulfilling its mission in a war scenario, operating in the interests of all arms and services of the Armed Forces. Its high efficiency was determined by the following important features:

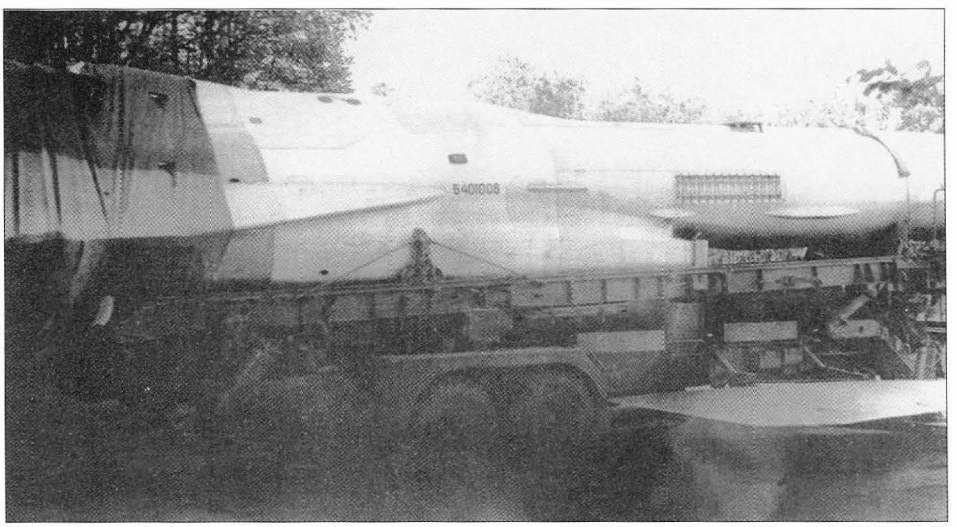
• the pilotless aircraft with zero-length launch did not require airfields or other permanent structures to operate;

• the mission preparation and launch took place in the field, that is, wherever necessary, using mobile ground support equipment;

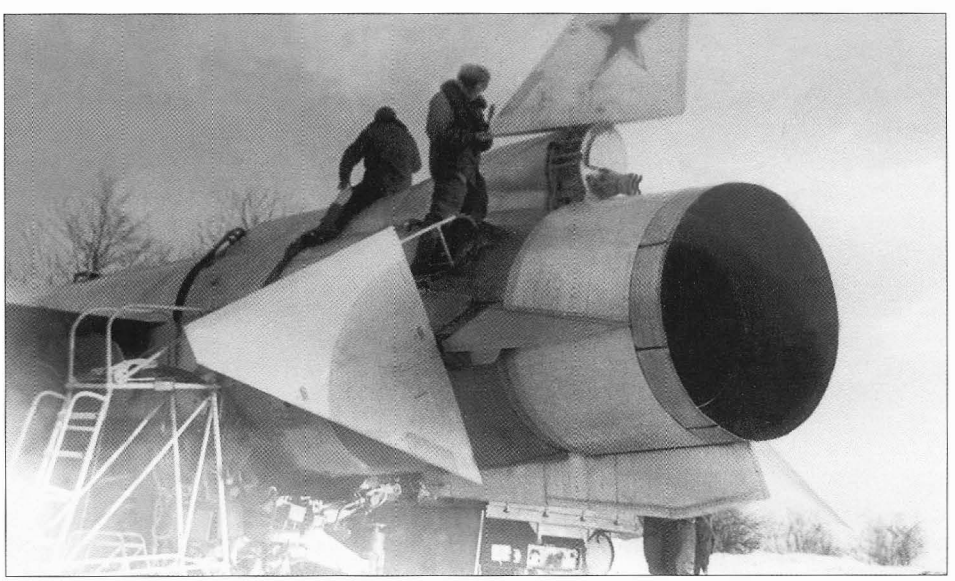
• the launch, and the subsequent recovery of the reconnaissance equipment capsule, could take place around the clock and in any weather, as long as the wind speed did not exceed 15 m/sec (30 kts);

• the Tu-123's high supersonic cruising speed at high altitudes rendered it less vulnerable even to strong enemy air defences.

Above: The 'head' of a Batch 8 Tu-123 is hoisted into position for mating with the 'body'. Curiously, this example has a late manufacture date, the c/n commencing with a 6 (640080...).



Above: The fuselage of Tu-123 c/n 5401006 awaits reassembly on an SURD-1 semitrailer. The rear end is covered by a tarpaulin to keep the rain out of the control surface actuators.



Reassembly is still in progress, hence the odd position of the port stabilator.

A Soviet Army officer poses with three incomplete Tu-123s and a ZiL-131 6x6 army lorry. The drones' brake parachute housings have yet to be fitted.

The DBR-1 offered the following advantages over the manned reconnaissance aircraft then in service with the Soviet Air Force:

• lower vulnerability to enemy air defences and anti-missile defences thanks to the Tu-123's smaller dimensions and higher cruising speed/altitude;

• higher chances of mission success, as the crew was unaffected psychologically and physically by enemy action;

• all-weather capability;

• the ability to operate in NBC contaminated areas.

Additionally, the DBR-1 system was markedly superior to the Soviet Air Force's manned reconnaissance assets as regards flight performance, reconnaissance range, the amount of intelligence gathered in a single sortie and the number of personnel required to fulfil the mission. Depending on the type and number of cameras fitted, a single Tu-123 could cover an area of 56,000 to 100,000 km² (21,621-38,610 sq miles) in a single sortie. In contrast, a PHOTINT-configured subsonic Tu-16R could photograph no more than 5,600 km² (2,162 sq miles) in a single sortie, while the supersonic Yak-28R tactical reconnaissance aircraft was limited to 4,530 km² (1,749 sq miles).

Consider this: a squadron of five Tu-123s staffed with 482 men could photograph a given area within an hour. To cover the same area, a group of 50 Tu-16Rs (which equals 1,612 men, including all ground personnel) required a minimum of three hours, while a group of 61 Yak-28Rs (which equals 1,107 men) also required at least three hours.

Of course, nobody's perfect, and no hardware's perfect either. The DBR-1's chief shortcoming was that most of the airframe and the engine were lost in each mission, only the jettisonable forward fuselage being reusable. Besides, the aircraft followed a pre-programmed course and could not be redirected towards a new objective after launch; also, it could not download intelligence to ground control centres in real time via data link.

The DBR-1 (Yastreb-1) system required a launch pad and a homing system to be set up. Mission preparation took place at a maintenance area which could cater for several launch pads.

The launch pad comprised:

• an SARD-1 (alias STA-30) self-propelled launcher consisting of a MAZ-537 heavy-duty 8x8 tractor unit (originally designed for towing ballistic missile TLVs and low-loader semi-trailers for transporting tanks and the like) and the special SURD-1 (ST-30) launcher semi-trailer with an elevating ramp;

• a KARD-1S (alias KSM-123) test equipment van/ground power unit used for checking the aircraft's systems prior to launch and starting up the cruise engine.

(As the reader will notice, the 'RD-1' bit was included into the designations of many hardware items associated with the '123'; it was a sort of product code, the letters standing for *raz**ved**chik **dahl'**niy* – 'reconnaissance aircraft, long-range'. By analogy with the La-17M/La-17R's support vehicles, the preceding letters indicated the function; thus, SA means ***star**tovyy avtomo**bil'*** and so on.)

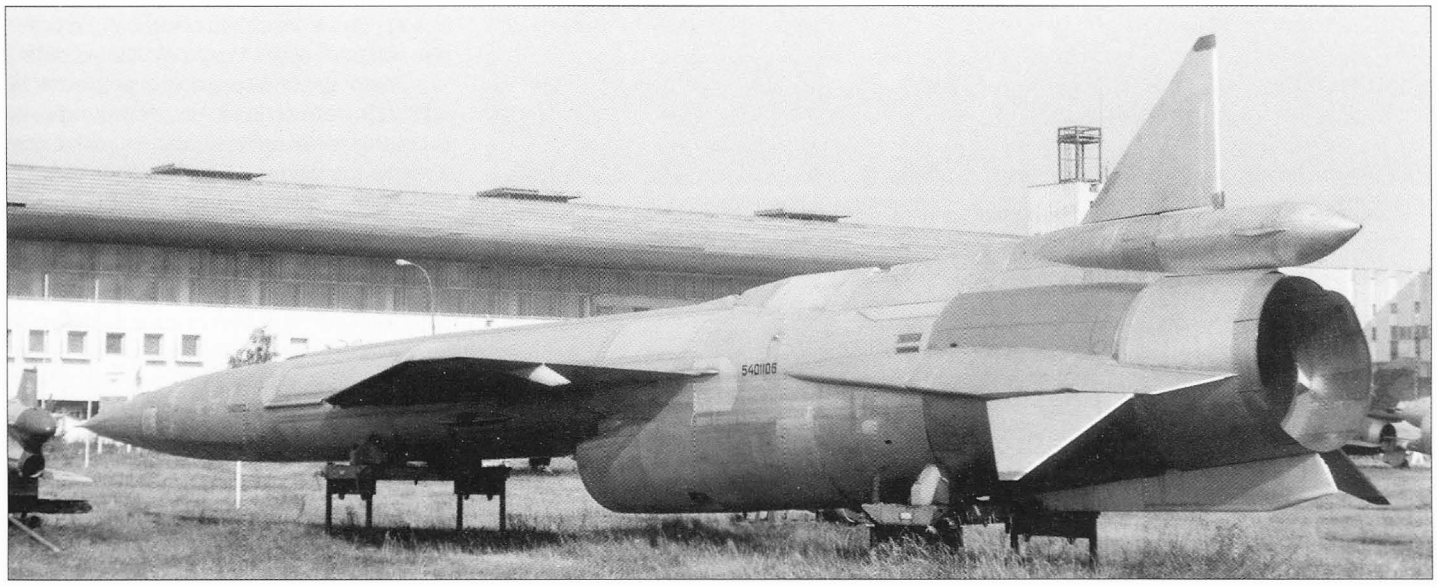
The launch command was given either from the cab of the STA-30 or from an external control box connected to the vehicle by a cable. The homing system directing the Tu-123 to the designated landing area ensured that the jettisoned forward fuselage (reconnaissance equipment capsule) would come down within a radius of 2-7 km (1.24-4.3 miles) from the 'X that marks the spot'.

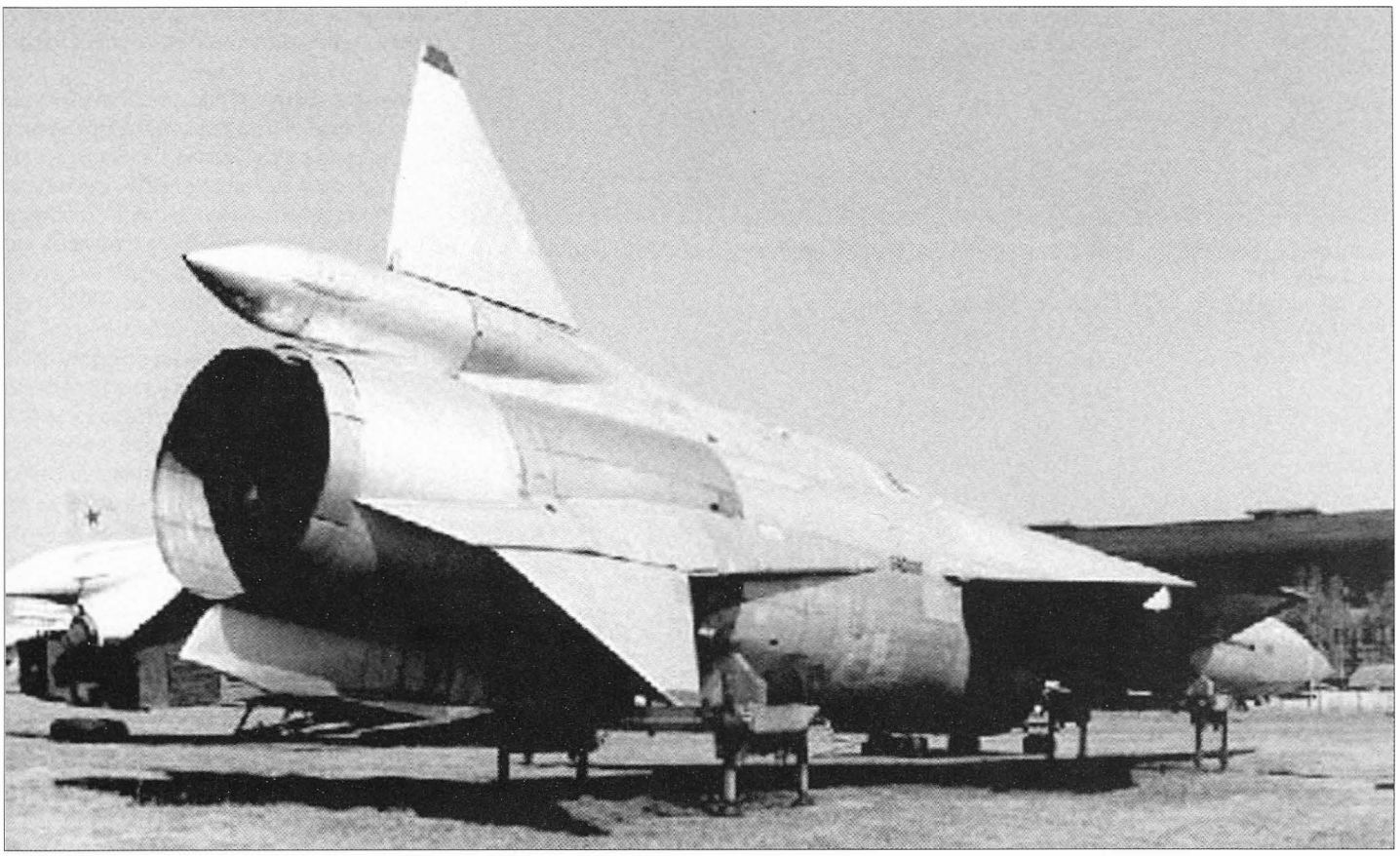
At the launch pad the aircraft was placed onto the launcher and systems checks were run, whereupon the mission programme was loaded into the autopilot and the launch took place. The Tu-123 left the ramp at an angle of

12°, blasting off and accelerating initially with the help of solid-fuel rocket boosters; at this stage it was subjected to an acceleration force of 5-6 Gs. Five seconds after take-off the boosters were jettisoned and the aircraft continued accelerating on the power of the cruise engine running in full afterburner; nine seconds after take-off the air intake's airflow guide was also jettisoned.

The programme entered into the control system before launch triggered the operation of the cameras and the SORD-1 identification friend-or-foe transponder (SO = *sistema opoznavaniya* – identification system), alias Khrom-Ya (Chromium; Ya is the last letter of the Russian alphabet). Once the objective had been completed and the Tu-123 made a U-turn and headed for home. When it came within 400-500 km (250-310 miles) of the launch site, the homing system was activated automatically to bring the aircraft back. The system's P-30 or P-35 360° search radar detected and identified the incoming UAV; then the PKRD-1RLS radar locked on and started tracking it, while the SAN-102 automatic guidance module (*sistema avtomatichеskovo navedeniya*) forming part of the PKRD-1RLS transmitted coded signals to the Tu-123's RU-6M remote control system to alter the aircraft's course.

When the aircraft reached the right spot, the system transmitted another command shutting down the engine, dumping the remaining fuel and putting the Tu-123 into a zoom climb in order to bleed off speed. The next command deployed the brake parachute





Two views of the Tu-123 that was displayed in the museum at Moscow-Khodynka. This is a composite airframe: the main part of the airframe is c/n 5401106, while the forward fuselage comes from c/n 5401005.

housed in the rear fuselage; after that, an on-board time delay mechanism released the locks holding the forward fuselage section in place and deployed the main parachute. As the forward fuselage drifted earthwards, four cantilever undercarriage legs were extended pneumatically to absorb the impact; the PKRD-1RLS radar tracked the forward fuselage section, determining its position with an accuracy margin of 100 m (330 ft). Meanwhile, the rest of the airframe descended, barely slowed down by the brake parachute; then came the inevitable thump and the aircraft was totalled. The next mission involved a fresh Tu-123. In theory the recoverable 'head' could be reused; in practice, however, this meant that a stock of 'headless birds' had to be kept, which was not viable economically. The only thing that was reused was the equipment inside the forward fuselage, after due checks to ascertain that it was serviceable.

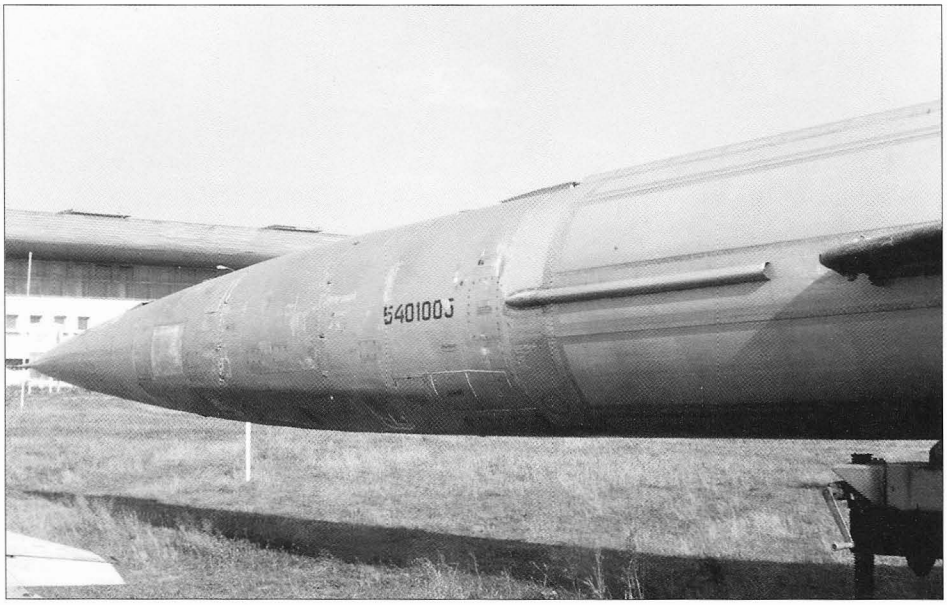
When the forward fuselage touched down, a Peleng-Ya (Bearing-Ya) radio beacon was activated automatically to indicate its position. Then the recovery team moved out in a TARD-1N (***trahns****portnyy avtomo****bil'***, alias ADNK-123) automobile or a helicopter to locate the forward fuselage and retrieve the film cassettes and the ELINT system's memory pack for delivery to the intelligence processing unit.

The DBR-1 system was in production for nine years (1964-72), a total of 52 aircraft being produced. The system saw service with the Air Force's reconnaissance units stationed in the Soviet Union's western Defence Districts – specifically, in Madona (Latvia) and near Khmel'nitskiy (the Ukraine) – until 1979. Each of these Independent Pilotless Reconnaissance Squadrons had a complement of six SARD-1 launchers and twelve Tu-123s. The system proved its viability on numerous occasions during practice launches at training grounds.

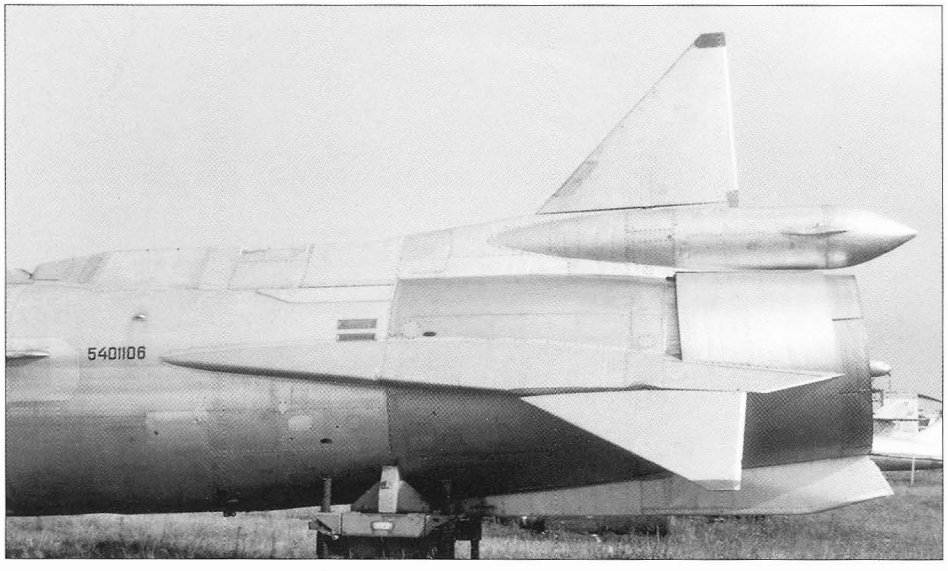
When the DBR-1 was finally phased out in the early 1980s, one of the reasons was the advent of the MiG-25RB et seq. This reconnaissance/strike aircraft, which came in several versions (MiG-25RB, 'RBK, 'RBS, 'RBT, 'RBV, 'RBSh and 'RBF), was capable of fulfilling the same mission but had the advantage of being reusable; after landing it could be prepared for a repeat mission fairly quickly if need arose. Moreover, it could carry an offensive warload, which the Tu-123 could not.

One of the few surviving examples of the '123' (Tu-123) ended up in the open-air museum at Moscow-Khodynka (which, as already mentioned, is currently closed) in early 1995. This exhibit was a composite airframe, being made up of two early-production examples; the forward fuselage is that of c/n 5401005 (that is, year of manufacture 1965, plant No.64 (the first digit is omitted to confuse would-be spies), batch 010, fifth aircraft out of six in the batch), while the rest of the airframe is c/n 5401106.

The basic Tu-123 reconnaissance drone and the DBR-1 (Yastreb-1) system evolved into several further projects.



Above: The forward fuselage of the Khodynka example. The port side oblique camera ports are just discernible.



The rear fuselage of the same aircraft, showing the tail unit design. This example lacks national insignia.

The '123' (Tu-123) in detail

Type: Supersonic reconnaissance drone. The all-metal airframe structure is made of heat-resistant alloys.

Fuselage: Semi-monocoque stressed-skin structure with a high fineness ratio. The fuselage cross-section changes from circular (in the forward fuselage) to elliptical with the longer axis vertical (in the area of the air intake) and back to circular, but of bigger diameter (in the rear fuselage).

The fuselage is divided into two major sections with a break point at frame 15. The recoverable *forward fuselage* weighs 2,800 kg (6,170 lb); it houses the reconnaissance equipment and part of the navigation/flight control suite. Structurally it is divided into three parts and may be disassembled for maintenance and film loading/removal; the mission equipment bay is pressurised. The tip of the nose cone carries a pitot boom.

To prevent damage to the mission equipment the forward fuselage was stored and transported in a special air-conditioned semi-trailer, being mated to the rest of the airframe during preparations for launch. The two sections are held together by four pneumatically actuated locks.

The expendable *rear fuselage* accommodates the engine, the fuel tanks, part of the navigation suite and the brake parachute container located above the engine nozzle. The

centre portion is occupied by fuel tanks, followed by a pressurised aft avionics bay, a bay for the air conditioning system serving it and a deionised water tank for cooling the control surface actuators. It incorporates the wing attachment fittings.

A semi-circular supersonic air intake with a fixed half-cone is located under the centre portion of the rear fuselage; it stands proud of the fuselage, the upper lip acting as a boundary layer splitter plate connected to the fuselage by a V-shaped fairing. In launch mode the air intake is partly covered by a semi-annular airflow guide used at subsonic speeds; it is jettisoned nine seconds after launch.

Three boxy fairings mounting the tail surfaces are positioned around the aft end of the rear fuselage, housing the electrohydraulic actuators; the upper one blends into the brake parachute housing. A shallow wiring conduit runs along the top of the fuselage.

Wings: Cantilever mid-wing monoplane with delta wings. Leading-edge sweep 67°, trailing-edge sweep approximately –2°, slight anhedral from roots. A thin airfoil with a sharp leading edge is used. Small sharply swept strakes are positioned at the trailing edge on the underside at about two-thirds span.

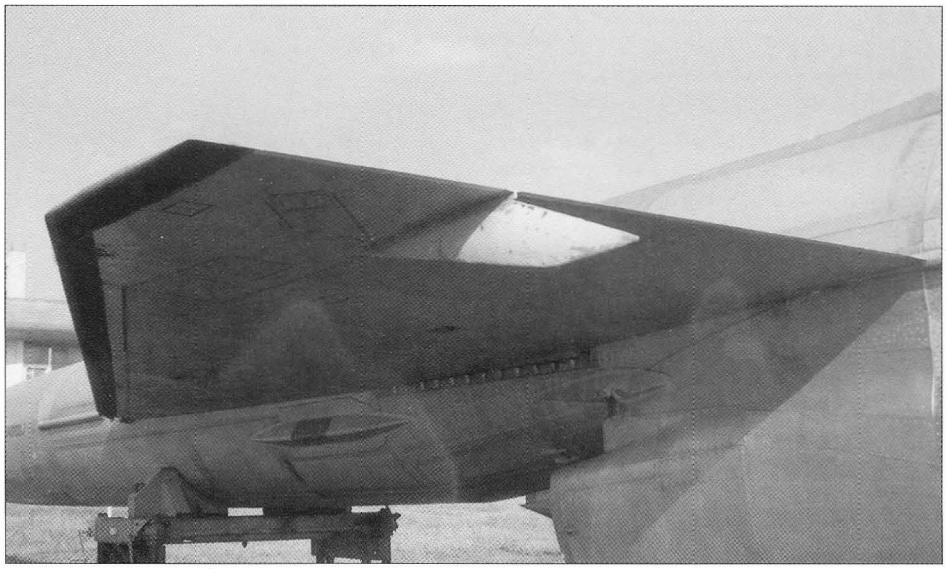
The wings are one-piece structures attached to the rear fuselage (the fuel tank section) by bolts, the wing/fuselage joint being covered by detachable fairings. They have neither ailerons nor high-lift devices, all control being exercised by the tail surfaces.

Tail unit: As for the '121' missile. All three tail surfaces have self-contained electrohydraulic actuators cooled by deionised water to protect them from the kinetic heating and the heat generated by the engine afterburner. A small ventral strake is provided to improve directional stability.

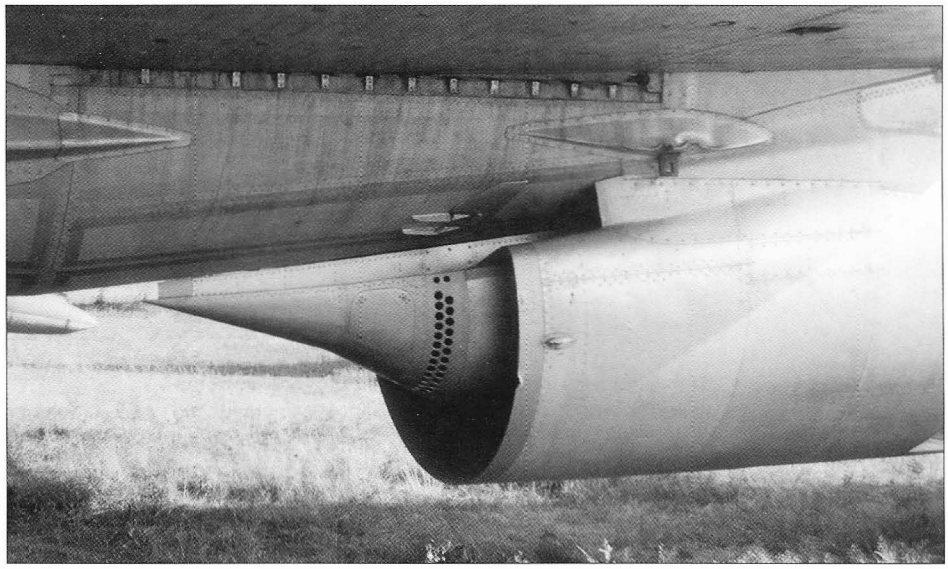
Landing gear: The forward fuselage features four pneumatically-actuated cantilever undercarriage legs tipped with pads. The forward pair is located between the air conditioning system bay and the pressurised camera bay, while the rear pair is located between the camera bay and a bay housing the Doppler speed/drift sensor and the parachute recovery system.

Powerplant: As for the '121' missile.

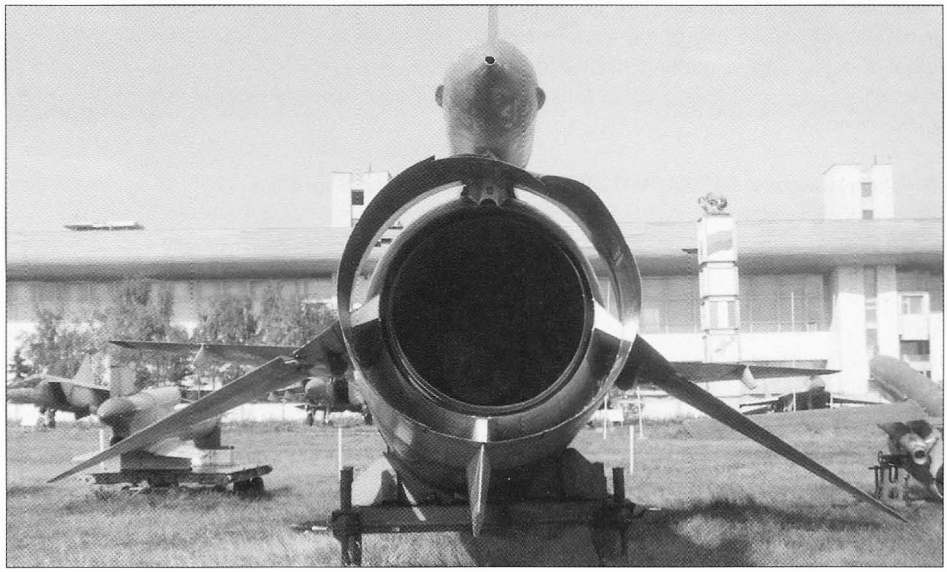
Control system: Autonomous control system enabling automatic flight along a pre-programmed route, with course correction by means of a Doppler speed/drift sensor. A radio control system is used at the final stage of the flight to guide the aircraft to the place where the nose section is to be jettisoned and recovered.



This view of the port wing shows the small underwing strake at about two-thirds span and the tandem attachment fittings for the rocket booster below the wing root.



Above: Close-up of the engine air intake, showing the perforated centrebody and the boundary layer evacuation gap.



This rear view shows the marked anhedral of the stabilators and the damaged ejector ring around the engine nozzle.

Fuel system: All fuel is carried in three integral tanks in the centre fuselage holding a total of 19,000 litres (4,180 Imp gal).

Avionics and equipment: The pressurised avionics/equipment bay in the forward fuselage (frames 8-15) houses the following equipment:

- an AFA-41/20M camera (f = 410 mm/16¾ in) for three-strip oblique photography (general-purpose PHOTINT);
- three AFA-54/100M cameras (f = 540 mm/21¼ in) for six-strip vertical photography (detail PHOTINT);
- an SUZ-RE photoelectric exposure meter;
- an SRS-6RD Romb-4A (Rhomboid) automatic ELINT pack (SRS = ***stahn****tsiya razved**ki svyaz**i*** – communications intelligence set) which registered the parameters of the potential adversary's radars it detected;
- the SNRD-1 Strela-B (Arrow-B) Doppler speed/drift sensor system;
- the SO-12U ATC/SIF transponder;
- the Peleng-Ya search assistance radio beacon;
- a self-contained power supply system.

The cameras were installed on automatic tilting mounts, 'firing' through camera ports with flush glazing made of special heat-resistant glass.

The pressurised rear avionics bay houses the SORD-1 IFF system, the modules of the RU-6M remote control system, the SOD-3 distance measuring equipment (***stahn****tsiya opredel**eniya dahl'**nosti***) and the APRD-1 autopilot.

Air conditioning and pressurisation system: The forward and aft avionics/equipment bays are pressurised by ram air from an air scoop on the port side of the fuselage. The air is fed into the air conditioning system located in an unpressurised bay of the forward fuselage; it comprises a cooling turbine and a chlorofluorocarbon cooling agent tank in the extreme nose.

'123M' (Yastreb-M) target drone

A single Tu-123 was completed as the prototype of a target drone version designated '123M' (Yastreb-M), the M standing for *mi**shen'***. This aircraft remained a one-off.

'123P' (Yastreb-P) manned reconnaissance aircraft project

Section K of the Tupolev OKB devised a fully recoverable manned version of the '123' designated '123P' (Yastreb-P), the suffix denoting *pilo**tee**ruyemyy* (flown by a pilot). Though not proceeded with, the project became a stepping stone towards the '139' fully recoverable pilotless reconnaissance aircraft (see below).

'123' nuclear-powered reconnaissance drone project

An even more ambitious project envisaged a version of the '123' featuring a nuclear powerplant (a turbojet with a built-in reactor). Like the other nuclear-powered aircraft projects, which were quite numerous in the 1960s, it did not progress beyond the technical proposal stage.

'123' superfast reconnaissance drone project

A further projected version of the '123' was a hypersonic aircraft designed to cruise at Mach 3 to Mach 4. Again, it never progressed further than the drawing board.

'123' cruise missile version project

The projected versions of the '123' included a cruise missile variant – effectively the '121 revisited' with a larger and heavier warhead.

'121'/'123' air-launched cruise missile version project

The Tupolev OKB contemplated the possibility of using the '121' or '123' as part of the DP air-launched cruise missile system with a maximum range of 12,000 km (7,453 miles). However, once again the idea was not taken further than the proposal stage.

Basic specifications of the '123' (Tu-123, DBR-1 Yastreb-1) reconnaissance drone

Length overall	27.825 m (91 ft 3⅝ in)
Height (fuselage axis level)	4.781 m (15 ft 8¹⁵⁄₆₄ in)
Wing span	8.414 m (27 ft 7¹⁷⁄₆₄ in)
Launch weight (with boosters), kg (lb)	35,610 (78,500)
Fuelled weight (without boosters), kg (lb)	28,611 (63,075)
All-up weight at end of mission, kg (lb)	11,450 (25,240)
Cruising speed, km/h (mph)	2,700 (1,677)
Technical range, km (miles)	3,560-3,680 (2,211-2,285)
Effective range, km (miles)	3,200 (1,987)
Flight altitude, m (ft):	
at the beginning of the photo run	19,000 (62,335)
at the end of the photo run	22,800 (74,800)

DBR-2 (Yastreb-2) long-range unmanned aerial recce system:

'139' (Tu-139) long-range reconnaissance drone

As early as when the SOR for the DBR-1 (Yastreb-1) aerial reconnaissance system was being formulated, the Tupolev OKB had considered the possibility of bringing back the entire UAV (and not just the reconnaissance equipment capsule) in one piece for later reuse. The first step in this direction was the '123P' manned reconnaissance aircraft project – which was rejected by the military.

Undeterred by this, as soon as the DBR-1 had entered production, in 1964 the OKB started work on the DBR-2 (Yastreb-2) fully recoverable long-range unmanned aerial reconnaissance system. The aircraft forming the core of the system received the designation '139' (Tu-139).

The aircraft represented an upgrade of the existing Tu-123. The objective was to turn it into an aircraft which, after completing its unmanned reconnaissance mission, would be capable of landing and be suitable for further use; the envisaged landing weight was 13,500 kg (29,760 lb). Designer L. N. Bazenkov was put in charge of the work on refining the DBR-1 system.

Structurally the '139' differed from the production '123' (Tu-123) UAV primarily in having new ogival wings (that is, with an S-shaped leading edge) similar to those of the first prototype Tu-144 supersonic transport (CCCP-68001). The parachute container above the engine nozzle was enlarged to accommodate a new combined brake/recovery parachute with a canopy area of 1,200 m² (12,903 sq ft) – the first of its kind in the Soviet Union. The tricycle landing gear retracting upwards into the nose and the air intake trunk was also new, since it had to absorb the weight of the entire aircraft.

When first deployed to kill the forward speed, the parachute opened only partially; then, after the aircraft had decelerated sufficiently, the parachute's rear lock was released and a special suspension system came into play so that the parachute was now attached close to the aircraft's CG. The parachute canopy now opened fully to provide a vertical speed of 10 m/sec (1,968 ft/min). A few seconds before touchdown a pack of solid-fuel retro-rockets attached to the parachute line fired, further slowing the descent to 2-3 m/sec (393-590 ft/min).

As far as its equipment and flight performance were concerned, the '139' was virtually identical to the production '123'.

Flight tests of the DBR-2 (Yastreb-2) system took place in the late 1960s and early 1970s and went well. Soon, however, work on this system was curtailed, as was all further

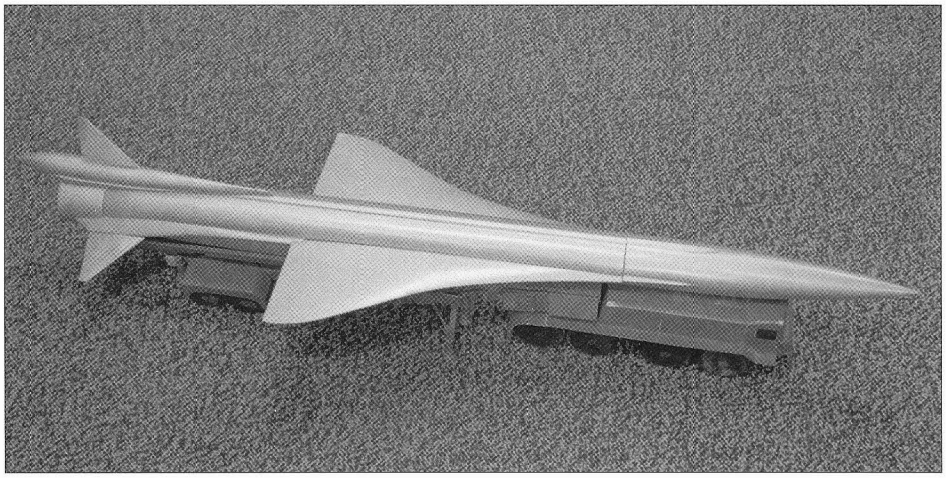
development work on supersonic strategic UAV systems. Nevertheless, the design and test experience gained with the '139' proved crucial, saving the day for all subsequent UAV programmes undertaken at the Tupolev OKB; the feasibility of using the drone at least ten times, with parachute landings on unprepared fields, was effectively demonstrated.

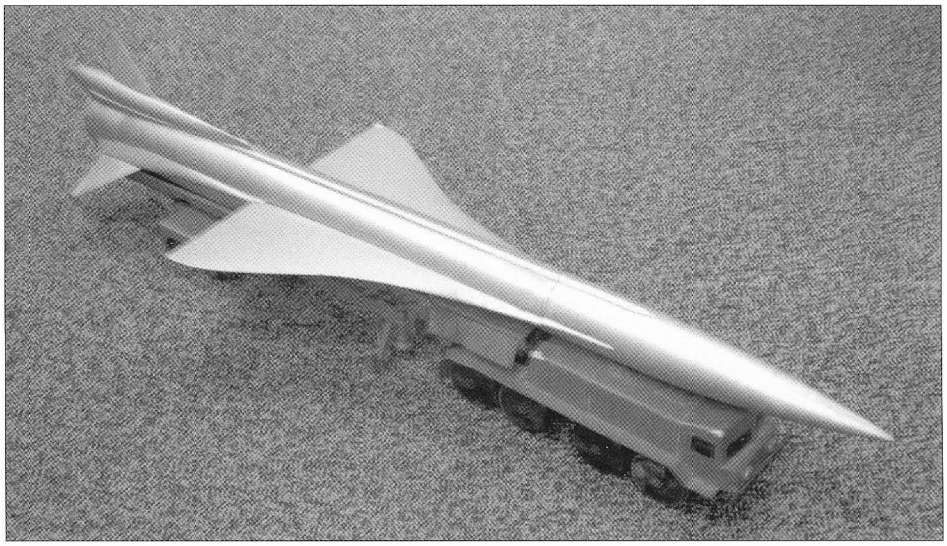
VR-3 (Reys) tactical unmanned aerial reconnaissance system:

'143' (Tu-143) tactical reconnaissance drone

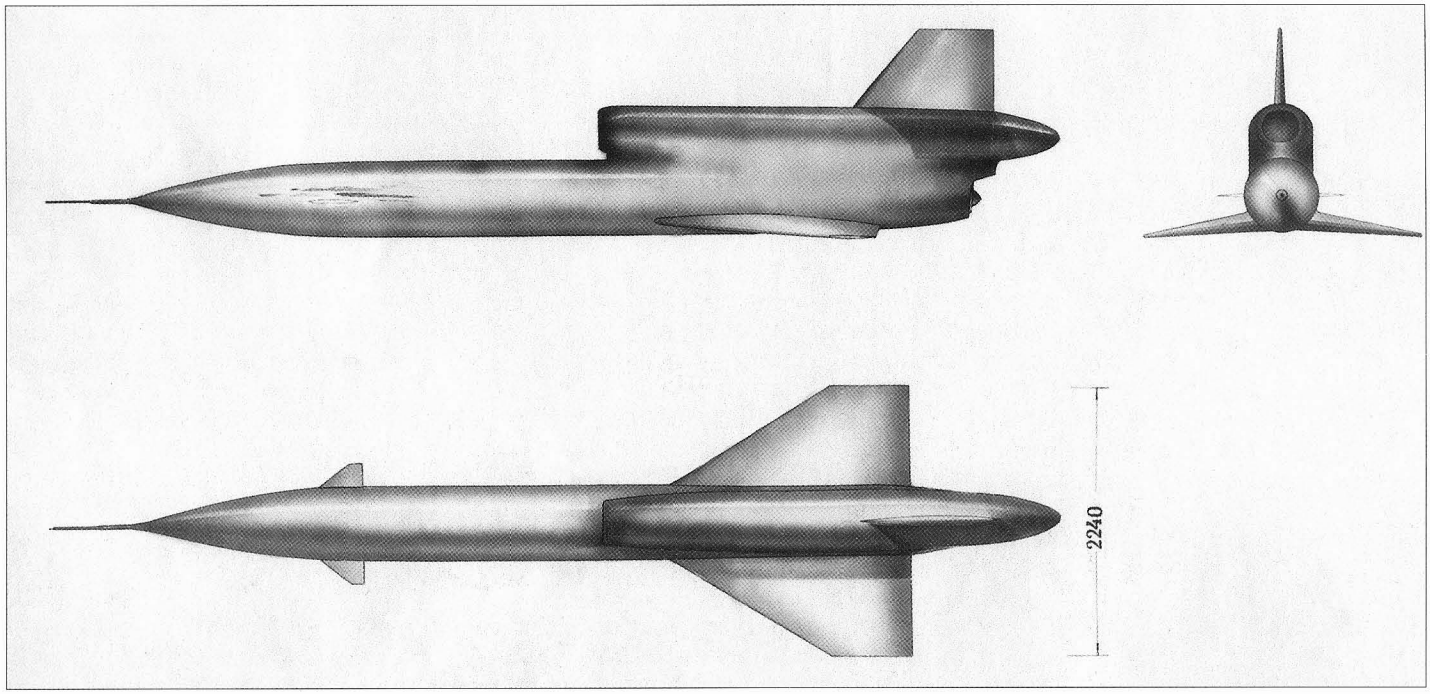
In the mid-1960s the Tupolev OKB began development of new tactical and theatre unmanned aerial reconnaissance systems. On 30th August 1968 the Council of Ministers issued directive No.670-241 ordering development of the new VR-3 tactical unmanned aerial reconnaissance system, alias Reys (Flight, as in 'scheduled or non-scheduled flight'), and the '143' (Tu-143) pilotless aircraft forming the core of the system. The VR-3 was to commence state acceptance trials in basic PHOTINT configuration in 1970; two other versions configured for TV and radiation reconnaissance were to follow in 1972.

The SOR for the new-generation tactical unmanned aerial reconnaissance system stated that the aircraft should be reusable and be capable of operating at both low and high altitudes (50-5,000 m/164-16,400 ft), as well as in mountainous areas. Special emphasis was placed on minimising the aircraft's RCS. Stringent requirements also applied to the navigation/flight control suite, which was to guide the aircraft to the objective with high

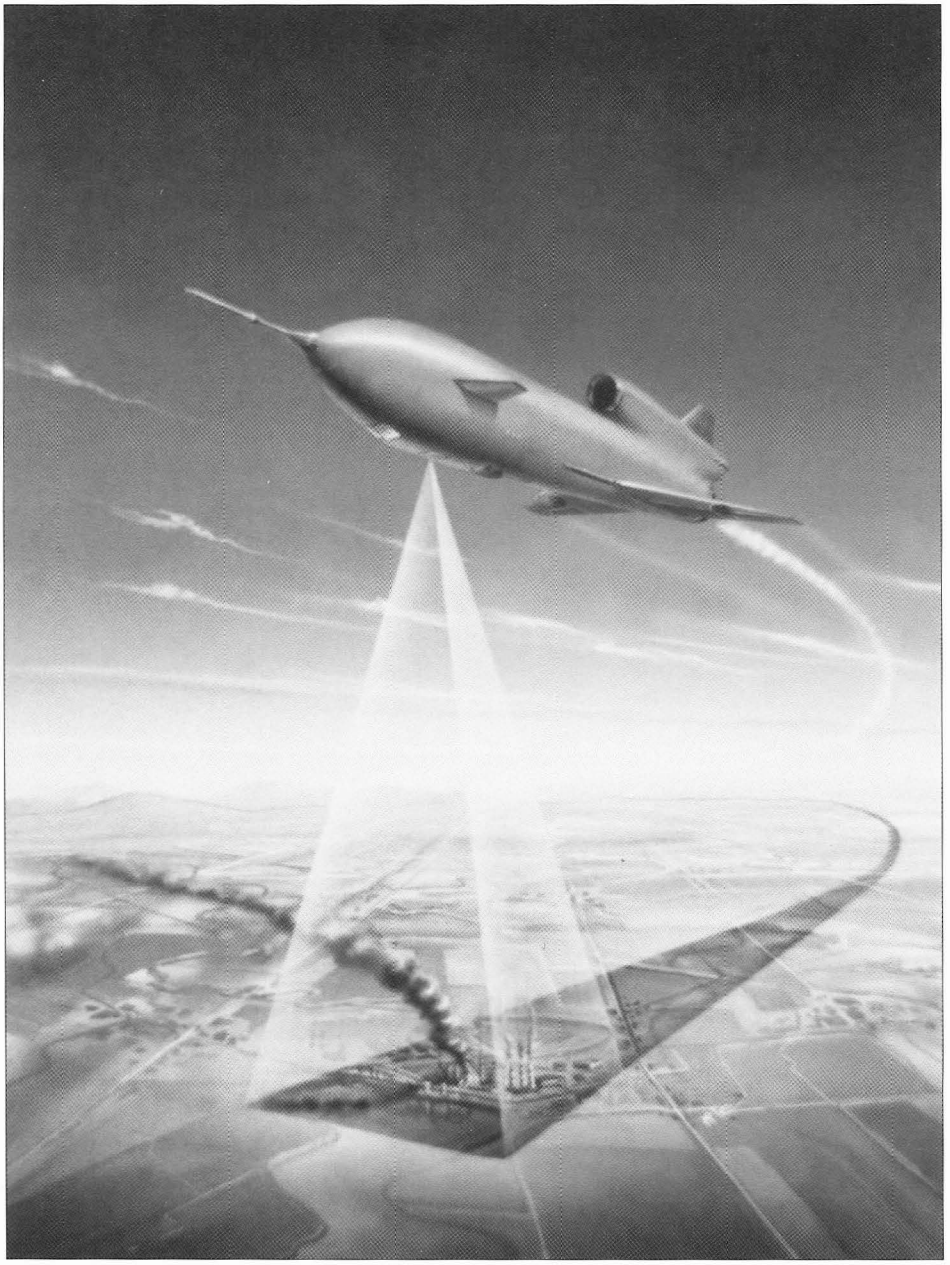




Top and above: A desktop model of the '139' (Tu-139) reusable reconnaissance drone. The new ogival wings are clearly visible. As in the case of the Tu-123, the forward fuselage is detachable to facilitate transportation.



A three-view drawing of the '143' (Tu-143) reconnaissance drone from the project documents.



A Tupolev OKB artist's impression of the Tu-143 in action.

accuracy and enable it to return and land in a 500x500 m (1,640x1,640 ft) clearing when the mission had been completed. The brief mission preparation time specified by the SOR called for the development of new avionics utilising state-of-the-art electronic components, as well as of a highly dependable engine.

Development of a new generation of unmanned aerial vehicles was led by G. M. Gofbauer who had by then become head of the Tupolev OKB's UAV section. The design staff of Section K made the most not only of their own OKB's design experience but also of that accumulated by their colleagues at other OKBs involved in UAV development.

The VR-3 (Reys) tactical unmanned aerial reconnaissance system was developed and tested within an incredibly short time. The successful maiden flight of the '143' prototype took place in December 1970; the state acceptance trials began in 1972, ending in 1976 with good results, whereupon the system was included into the Soviet Army inventory. Series production began while the state acceptance trials were still in progress; the Kumertau Machinery Plant in Bashkiria manufactured the first pre-production batch of ten in 1973. Full-scale production got under way soon afterwards, continuing until 1989; a total of 950 Tu-143 drones was built.

The '143' was manufactured in two versions with different (and interchangeable) nose sections housing the mission equipment; one had a PHOTINT suite while the other was fitted with a TV camera, relaying the picture to ground command, control, communications and intelligence (C^3I) centres in real time. The aircraft could also be equipped for radiation reconnaissance (RINT), the intelligence gathered in this configuration again being downloaded to C^3I centres via data link.

The VR-3 system was intended for tactical reconnaissance in the frontline area at up to 60-70 km (37.3-43.5 miles) from the FLOT by photographing or video filming large-area targets or strips of terrain and measuring radiation levels en route. It was suitable for reconnoitring troop concentrations, combat vehicles, fortifications and other structures (bridges and so on). The system enabled/ensured:

- low-altitude reconnaissance if the cloudbase was low;
- stealthy mission preparation and launch from unprepared locations;
- autonomous operation and high mobility allowing rapid redeployment to a new location, using the system's own vehicles;
- almost real-time delivery of intelligence if data link systems were used.

Operation of the VR-3 system included the following:

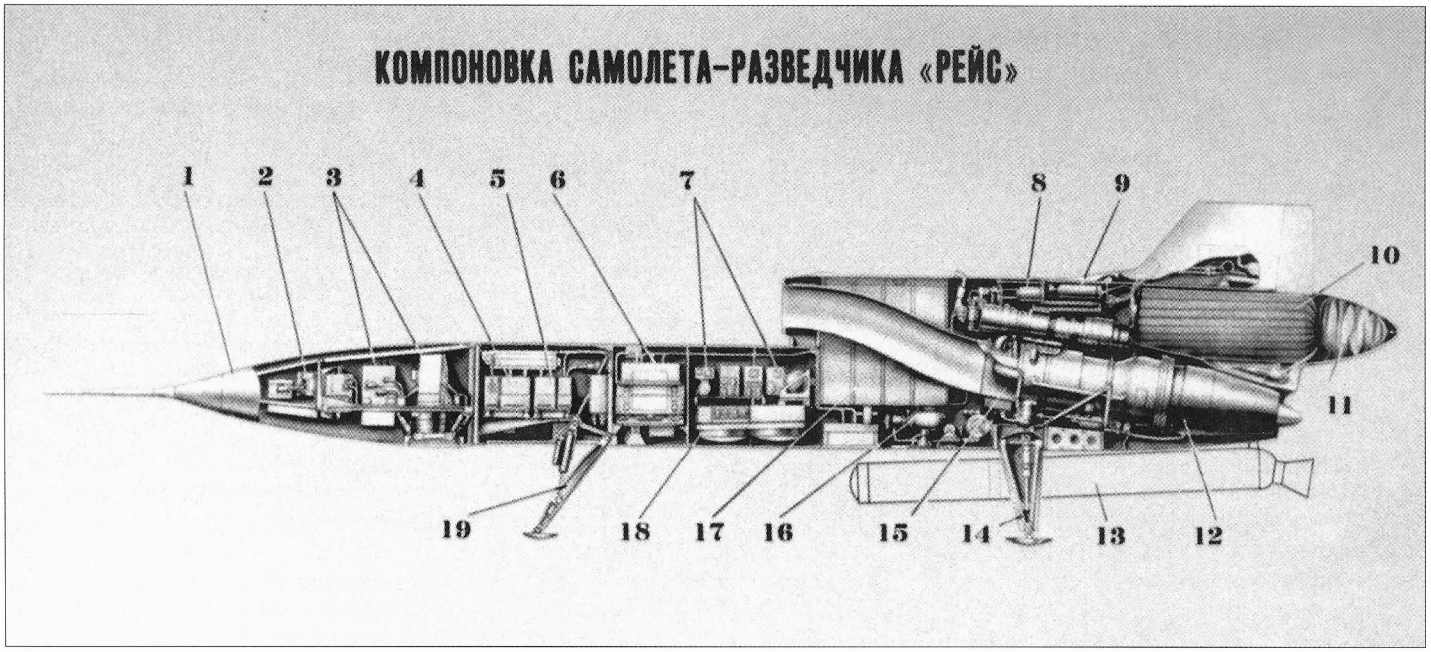
- mission preparation and launch of the '143' aircraft from a self-propelled launcher at wind speeds up to 15 m/sec (30 kts);
- automatically controlled flight at predetermined altitudes;
- programming of the flight route and the reconnaissance equipment operation times;
- actual PHOTINT, TV reconnaissance and RINT;
- delivery of the exposed films to the required spot for collection and transmission of intelligence to C^3I centres via data link.

The system included the following components:

- the '143' (Tu-143) pilotless reconnaissance aircraft featuring a programmable automatic flight control system and alternative mission equipment sets;
- a set of transportation, support, launch and maintenance vehicles and equipment for the '143';
- mobile intelligence reception, processing and transmission facilities.

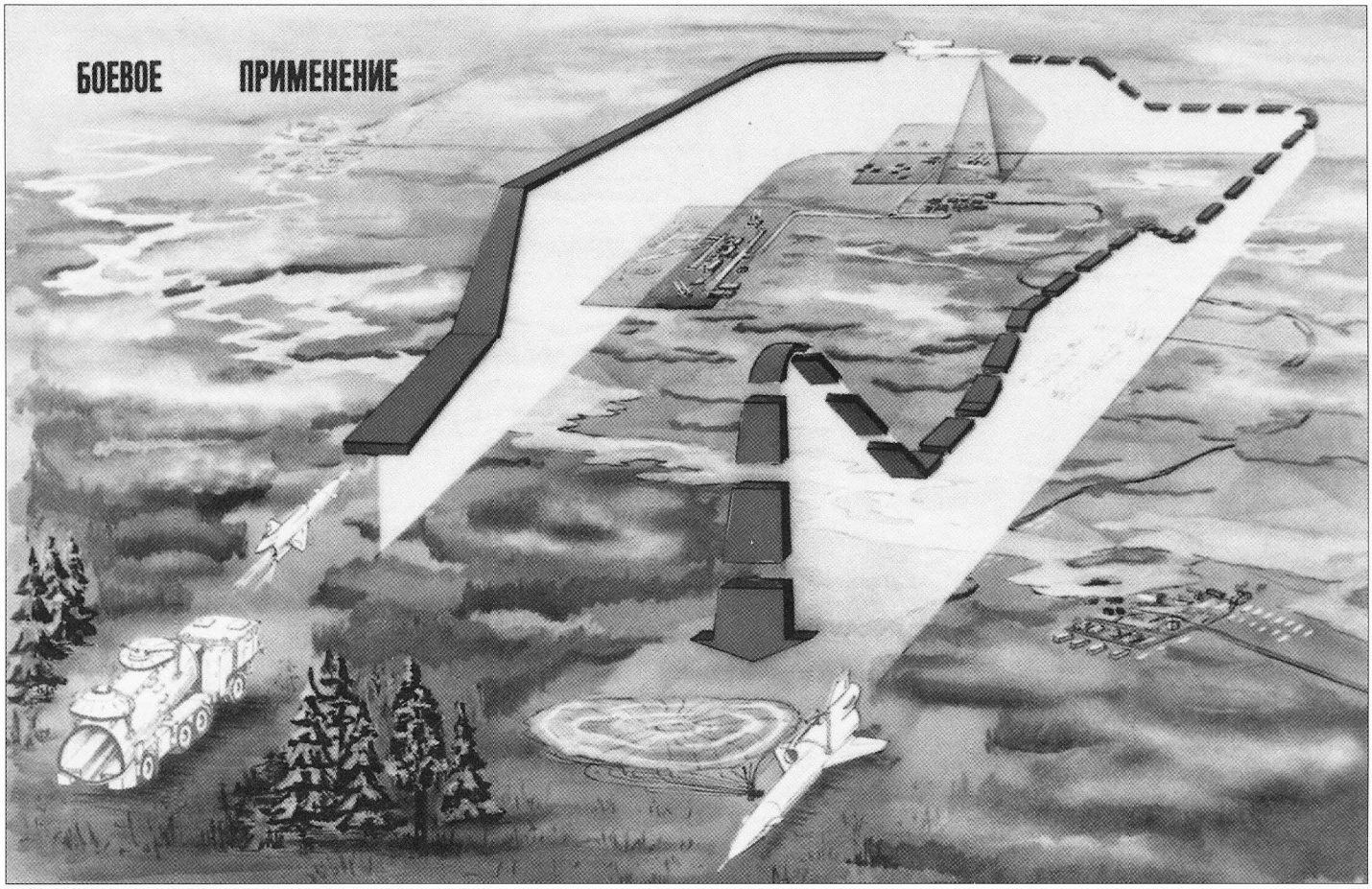
At the launch pad the aircraft was placed into the tube of the SPU-143 self-propelled launcher (*samo**khod**naya pooskо**va**ya oosta**nov**ka* – SP launcher) by a TZM-143 transporter/loader vehicle (***trahns**portno-zarya**zha**yushchaya ma**shin**a* – TLV). Both were based on the Bryansk-built BAZ-135MB 8x8 chassis – a derivative of the BAZ-135LM theatre ballistic missile TEL (née ZiL-135LM) which was a successor to the ZiL-134K mentioned in the previous chapter. The TZM-143 served both for carrying the Tu-143 to the launch site and for recovering it after landing.

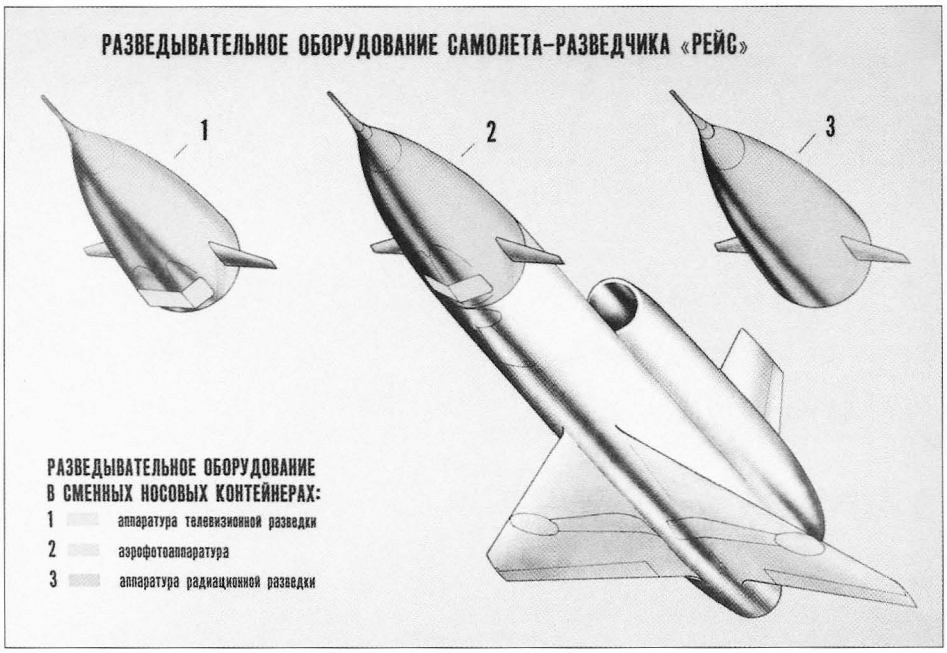
On-site and scheduled maintenance of the Tu-143 at the maintenance area were



Above: This cutaway drawing shows the internal layout of the Reys (Tu-143) tactical reconnaissance drone.
1. Interchangeable nose section housing the mission equipment (the PHOTINT version is shown here); 2. Telemetry system transmitter; 3. Aerial cameras; 4. Computer; 5. Radio altimeter; 6. Autopilot; 7. Electric system equipment; 8. Hydraulic system equipment; 9. Retro-rocket; 10. Recovery parachute; 11. Brake parachute; 12. TR3-117 cruise engine (sustainer); 13. SPRD-251 solid-fuel rocket booster; 14. Main landing gear unit; 15. Oil tank; 16. G load protection device; 17. Fuel tank; 18. DISS-7 Doppler speed/drift sensor system; 19. Nose landing gear unit.

Below: This diagram illustrates the Tu-143's mission profile. The drone flies at low level en route to and from the target, climbing prior to the actual photo run(s) and climbing again after engine shutdown to lose speed before the recovery parachute is deployed.

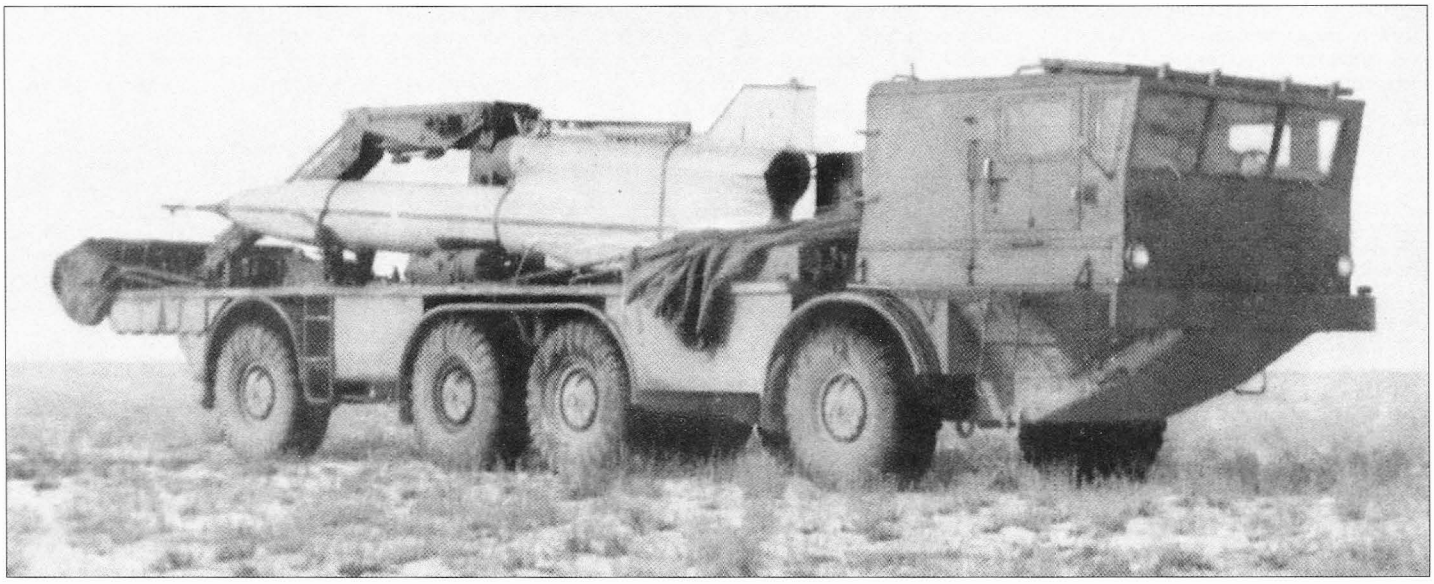


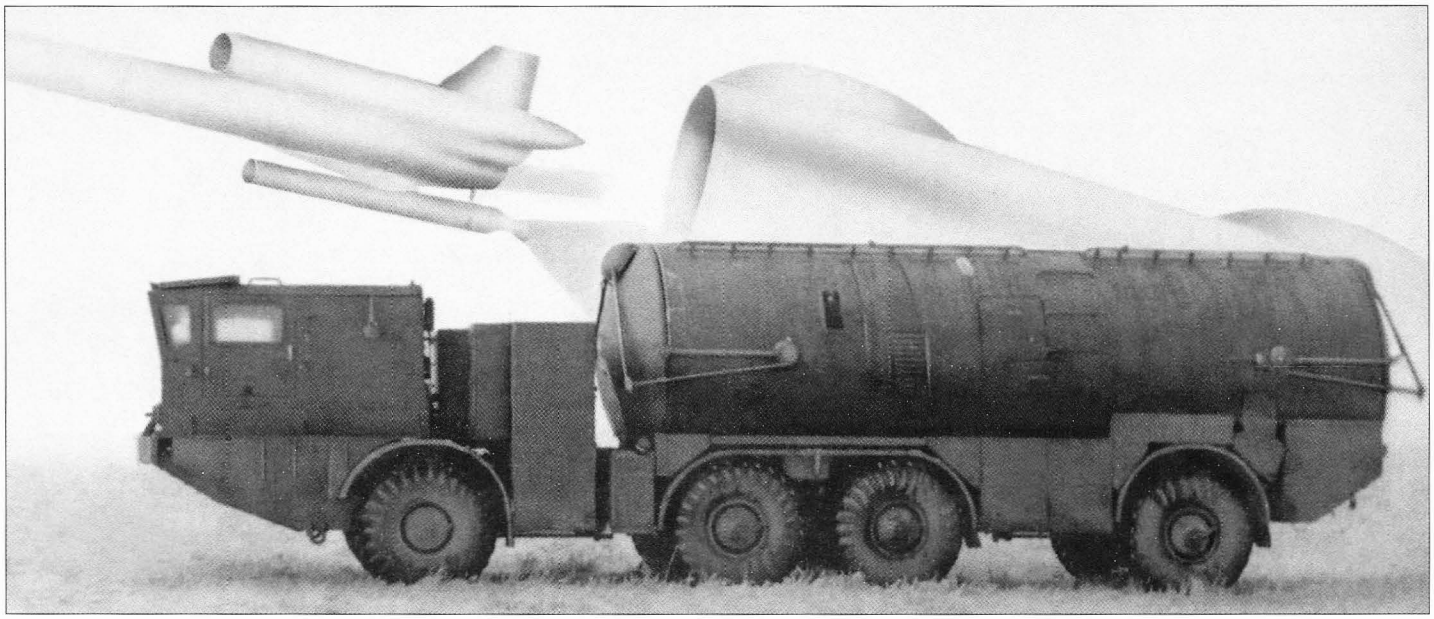


Left: This drawing illustrates the three possible configurations of the Reys (Tu-143) reconnaissance drone. Left to right: TV reconnaissance version, photo reconnaissance version and radiation reconnaissance version.

Below: The TZM-143 transporter/loader vehicle based on the BAZ-135MB can carry two Tu-143 drones at a time (they are placed to face in the opposite directions). The drones are handled by the telescopic hydraulically-powered crane mounted in the centre of the cargo platform. The eight-wheel drive BAZ-135 has a very distinctive '1-2-1' axle arrangement with steerable front and rear axles improving manoeuvrability without sacrificing cross-country capability. The current 'squarehead' BAZ-135MB is diesel-powered, unlike the original BAZ-135LM which had two V8 petrol engines side by side and a less spacious cab.

Bottom: The SPU-143 launcher is also based on the BAZ-135MB. The front and rear covers of the launch tube are raised before launch.





performed by means of KIPS-1 and KIPS-2 test equipment vans and an APA-50M ground power unit (*aero**drom**nyy pooskovoy agre**gaht***); together these three vehicles formed the KPK-143 checkout and test suite (*kon**trol'**no-pro**ve**rochnyy **kom**pleks*). The maintenance area also featured fuel and oil bowsers, an air charging vehicle, a mobile crane, fire engines and ordinary dropside lorries. The Tu-143 drones were stored and delivered to the maintenance area in special containers.

The landing area selected for the '143' needed to be a clearing measuring at least 700 x 700 m (2,300 x 2,300 ft). A special team would clear the way to it for the TZM-143 and the intelligence recovery lab vehicle, cutting down trees and reinforcing areas of soggy ground where necessary.

The POD-3 intelligence reception, processing and transmission unit (*poonkt pree**yom**a, obra**bot**ki i deshif**rov**ki*) ensured timely reception of the intelligence data gathered by the aircraft, its processing and supply via army communications channels to Those Who Need To Know. The unit consisted of the following components:

- a photo lab for developing, printing and deciphering the films;
- a laboratory for receiving and taping the video imagery or RINT data transmitted by the aircraft;
- an intelligence recovery lab vehicle;
- an ESD-30 self-contained diesel-powered generator (elektrostahntsiya dizel'naya – 'diesel power station').

The interaction of the VR-3 (Reys) system's components proceeded as follows. At the maintenance area the inhibited mission equipment modules were returned to active status prior to installation; the aircraft's systems were tested module by module and as a whole. The Tu-143 was fully equipped for the mission, including installation of the recovery system's explosive cartridges; the fuel and oil tanks were filled and the air bottles charged, and all systems were rechecked once again.

In transport mode on the TZM-143 and the SPU-143, the aircraft was secured by special supports. On the former vehicle the Tu-143 was transported without the SPRD-251 solid-fuel rocket booster (*start**ovyy porokhovoy ra**ket**nyy **dvig**atel'*), while in the case of the launcher the drone was carried with the booster attached.

The *Kvad**raht*** (Square; must be a reference to grid squares) navigation system guided the SPU-143 to the designated launch location with a certain accuracy margin. The flight programme file, which was written in advance, was loaded into the drone's BVD-1 module (*blok **vvod**a **dahn**nykh* – data entry module) immediately before launch. Then the mission crew sitting in the launcher's cab ran the pre-launch checks; once the 'Ready for launch' annunciator light lit up, the Tu-143's Izotov TR3-117 cruise engine was started up and the launch button pressed. The rocket booster fired and the aircraft left the launch ramp at an angle of 15°. Safe separation of the spent booster was ensured by a special cartridge whose detonation was triggered by the falling pressure in the booster's combustion chamber.

Once the Tu-143 had entered cruise mode, the ABSU-143 automatic flight control system (*avtoma**tich**eskaya borto**va**ya sis**tem**a oopra**vlen**iya* – AFCS) initiated a pre-programmed climb and acceleration. Throughout the flight the AFCS stabilised the aircraft around its CG, computed the distance covered by the aircraft and compensated for wind drift. In addition, the AFCS issued the following information and commands to the mission equipment and the parachute recovery system:

- distance covered since launch;
- prescribed flight level;
- actual altitude above ground level;
- commands to activate and switch off the reconnaissance equipment;
- the command to shut down the cruise engine when the aircraft came within the prescribed distance of its destination;
- the command to activate the parachute recovery system timer.

Primary PHOTINT was performed along the entire route. When up-to-the-minute information was required, TV reconnaissance was performed to obtain more specific information about the condition of targets with known coordinates.

Missions were flown in the daytime only. The intervals at which the camera shutters fired were set automatically, depending on the flight level, which was determined by the AFCS. As the TV system transmitted the image to the POD-3 intelligence processing unit, the picture was accompanied by range marker signals generated by the AFCS to give an idea what part of the terrain was on the screen. Reception of the TV signal from the drone was possible within eyesight of the drone.

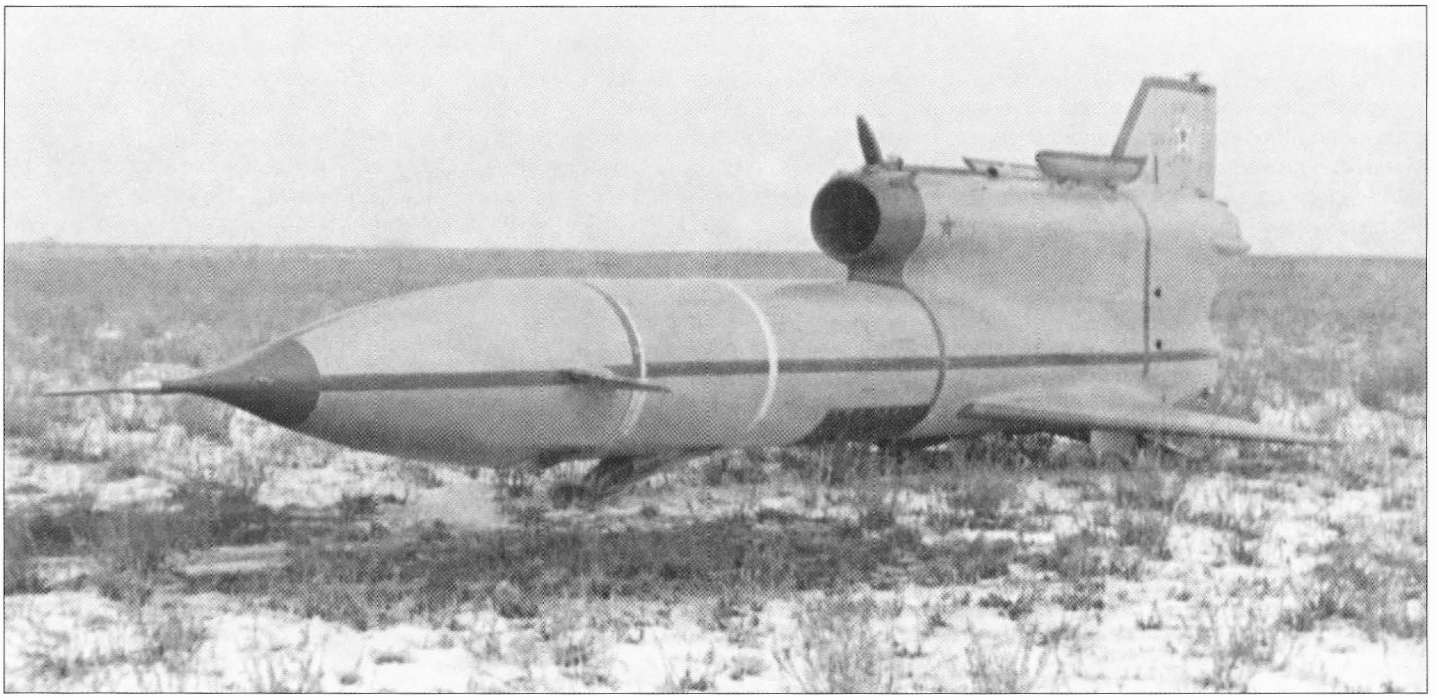
When the objective had been completed, the drone landed in the designated area. The landing was divided into two stages. First, the engine was shut down and the Tu-143 entered a zoom climb to kill the forward speed. At the end of this manoeuvre a brake parachute housed above the engine jetpipe was deployed; 11 seconds after the initiation of the landing sequence the brake parachute was released and the main parachute deployed, the aircraft descending vertically. An on-board time delay mechanism consecutively released the locks attaching the parachute line to the fuselage to change the aircraft's attitude; it also extended the landing gear and the impact probes. When the latter touched the ground, a retro-rocket with multiple nozzles fired, reducing the vertical speed from 6 m/sec (1,180 ft/min) to 2 m/sec (393 ft/min). At the moment of touchdown the parachute and retro-rocket were jettisoned automatically, triggered by landing gear oleo compression, to prevent the aircraft from being blown over by ground winds. Thereupon the recovery team collected the intelligence gathered during the mission and salvaged the aircraft to be prepared for the next mission.

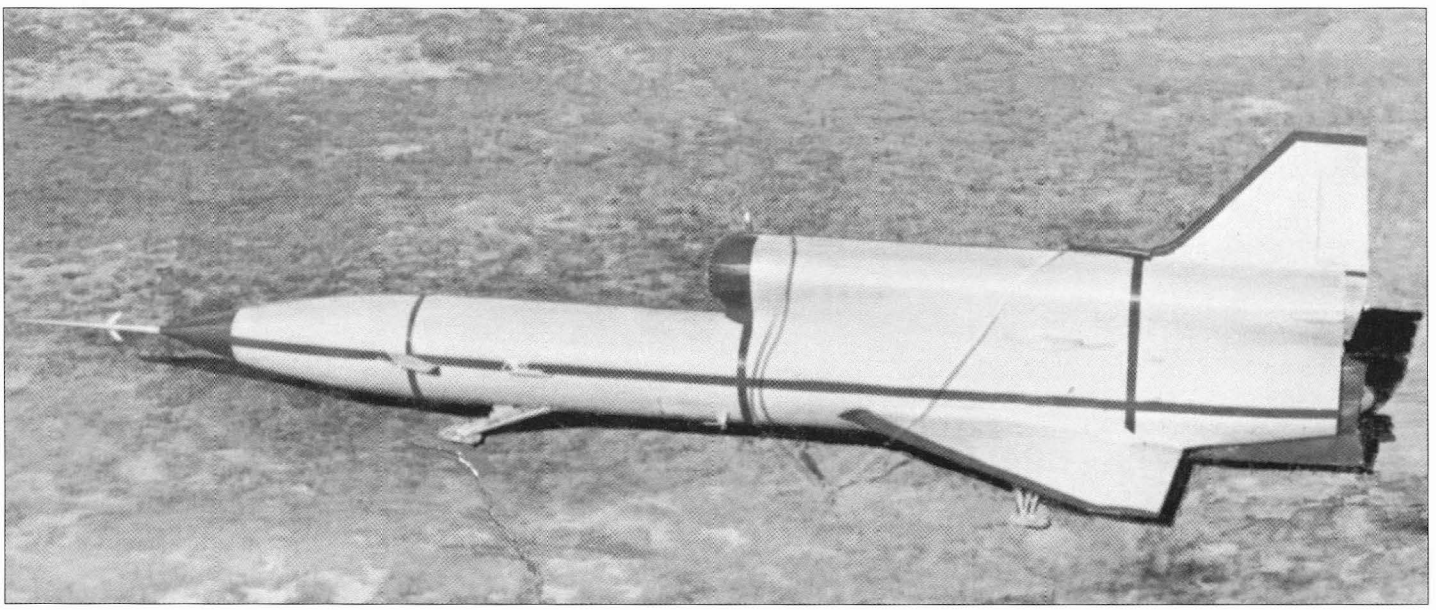
The VR-3 (Reys) tactical unmanned aerial reconnaissance system was fairly quickly mastered by the Soviet Armed Forces, earning a good reputation. Originally designed to an Air Force specification, it found use with other arms and services as well. During combined arms exercises the VR-3 demonstrated major advantages over manned tactical reconnaissance aircraft fitted out with similar mission equipment. One of these advantages was the Tu-143's navigation/flight control suite enabling a higher-precision approach to the target than that of the MiG-21R and the Yak-28R; accurate navigation was one of the decisive factors affecting the efficiency of aerial reconnaissance. Stabilisation of the drone's flight, coupled with the controlled environment in the equipment bay, provided the optimum operating conditions for the mission equipment, ensuring high-quality intelligence. The cameras fitted to the Tu-143 allowed objects 20 cm (7⅞ in) long to be discerned on photos taken at 500 m (1,640 ft) and 950 km/h (590 mph).

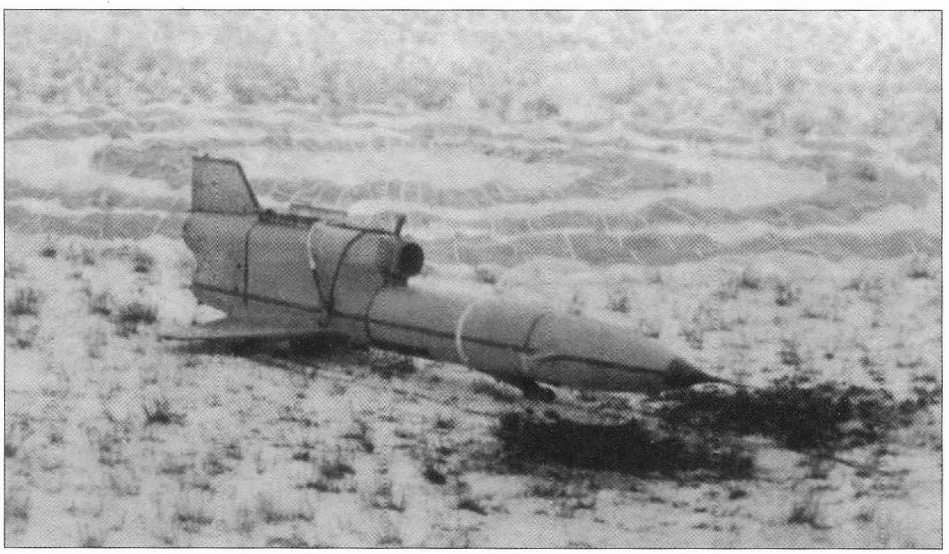
The system acquitted itself well during operations in mountainous areas; the Tu-143 could take off and land at locations situated up to 2,000 m (6,560 ft) above sea level and operate above mountain ranges up to 5,000 m (16,400 ft) high. In these conditions the VR-3 system was virtually invulnerable to enemy air defences (small arms fire and SAMs), which gave obvious advantages on the southern theatre of operations.

The units operating the VR-3 system were divided into squadrons. Each squadron had a complement of twelve Tu-143 drones and four SPU-143 launchers, the necessary equipment for mission preparation and location/recovery of the drones after the mission, a command post, communications centres, an intelligence reception, processing and transmission unit and a maintenance unit where the drones were stored. The system's main components were mobile.

The VR-3 (Reys) tactical unmanned aerial reconnaissance system was exported to Czechoslovakia, Romania and Syria. The Syrians used it in actual combat in 1982 for reconnoitring Lebanese territory captured by





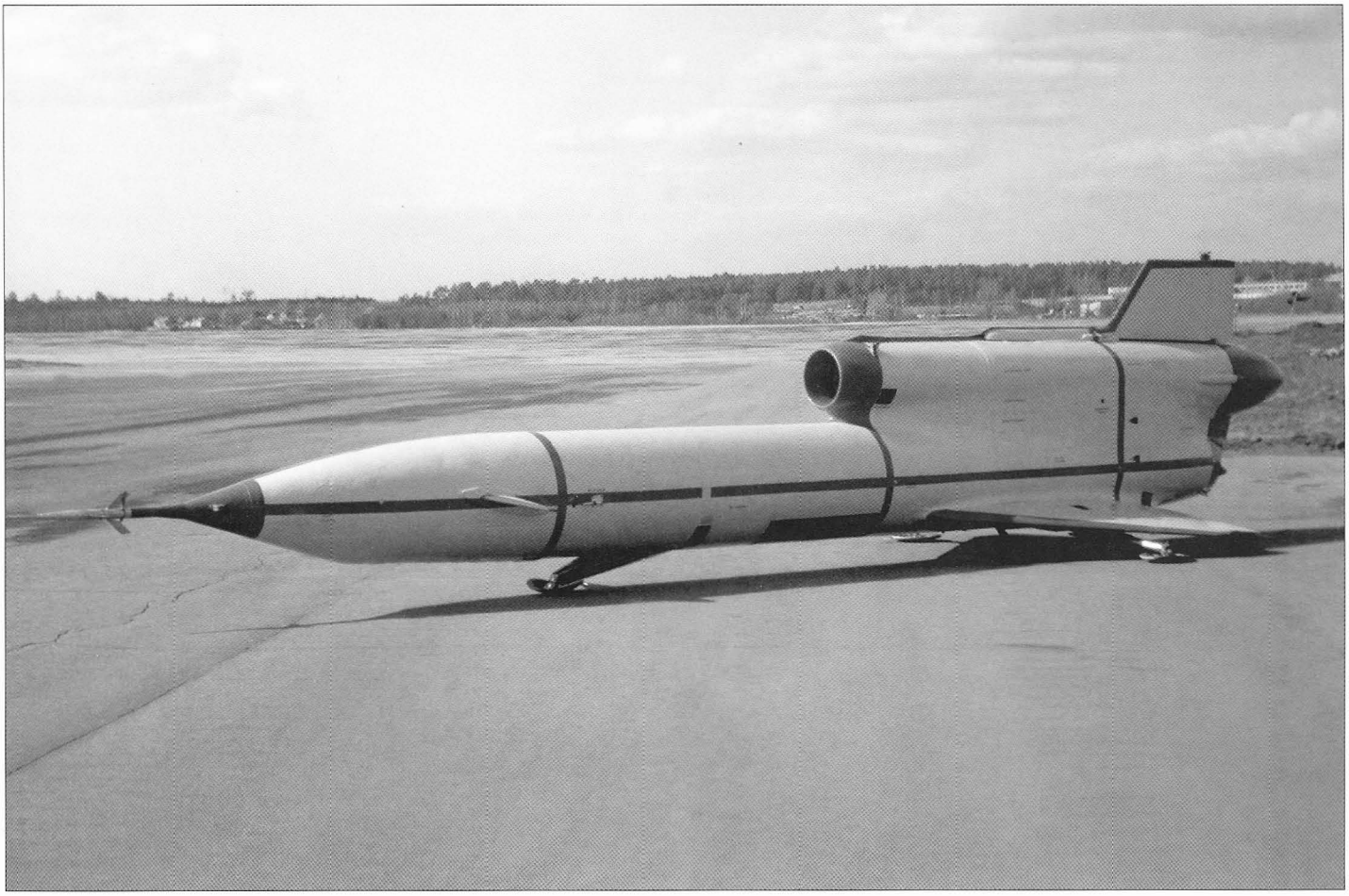


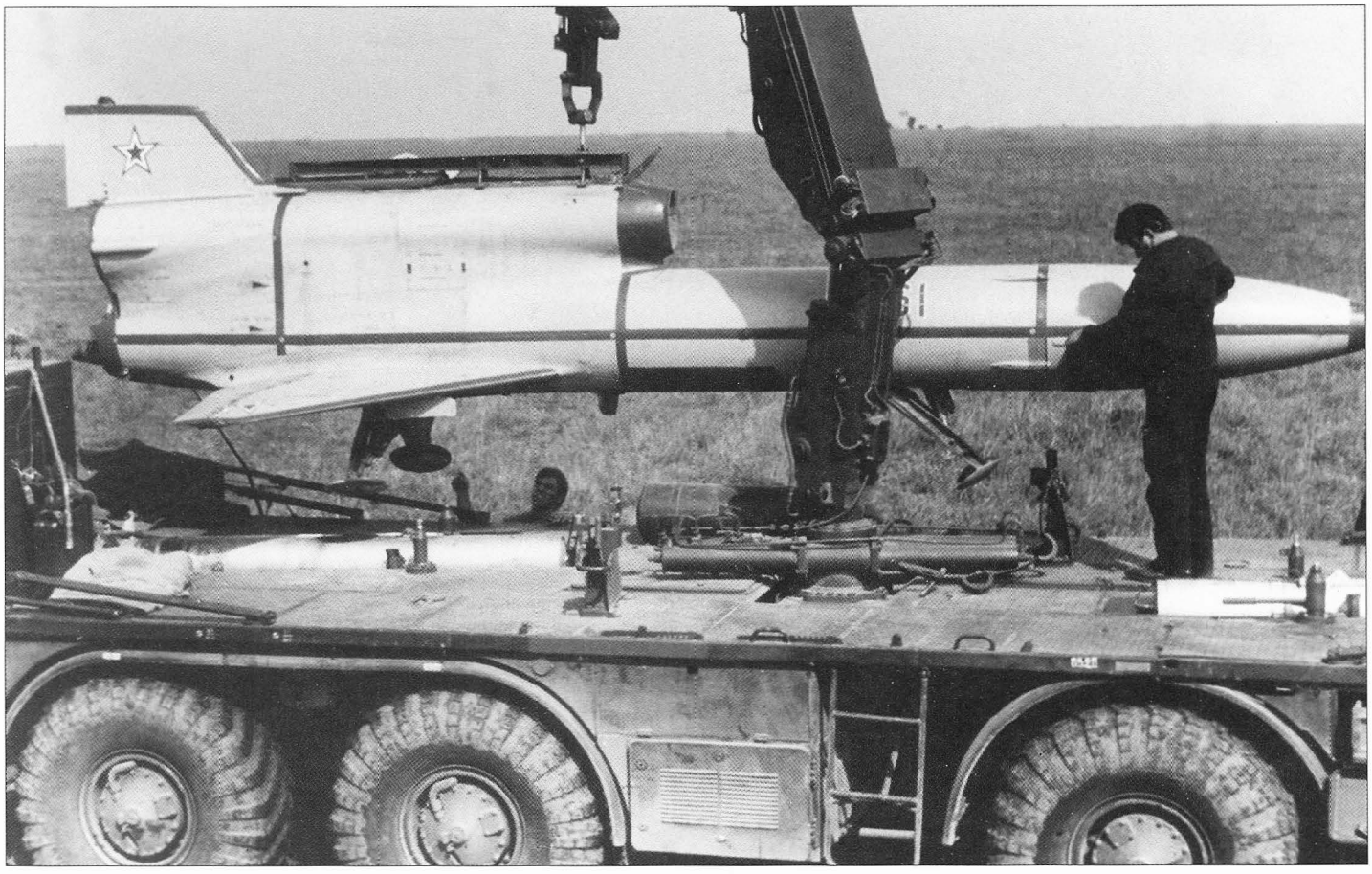
Top: A red-starred '143' (Tu-143) in the grey and red colours typical of the type sits where it has landed after a test flight in late autumn (judging by the scant snow cover). The clamshell doors of the recovery parachute bay immediately ahead of the fin are open and the landing gear oleos are fully compressed by the landing impact. Note the dark dielectric panel of the Doppler speed/drift sensor ahead of the wings.

Above: Another '143' after a test flight. This one has a taller tail, a nose probe equipped with air data system pitch/yaw vanes and no national insignia.

Left: Another view of the '143' pictured at the top of the page. The recovery parachute lies beyond; note the parachute line dangling from the top of the air intake fairing.

Opposite page: Two views of an immaculate '143'. The high incidence of the canard foreplanes is obvious; note also the longer nozzle centrebody.



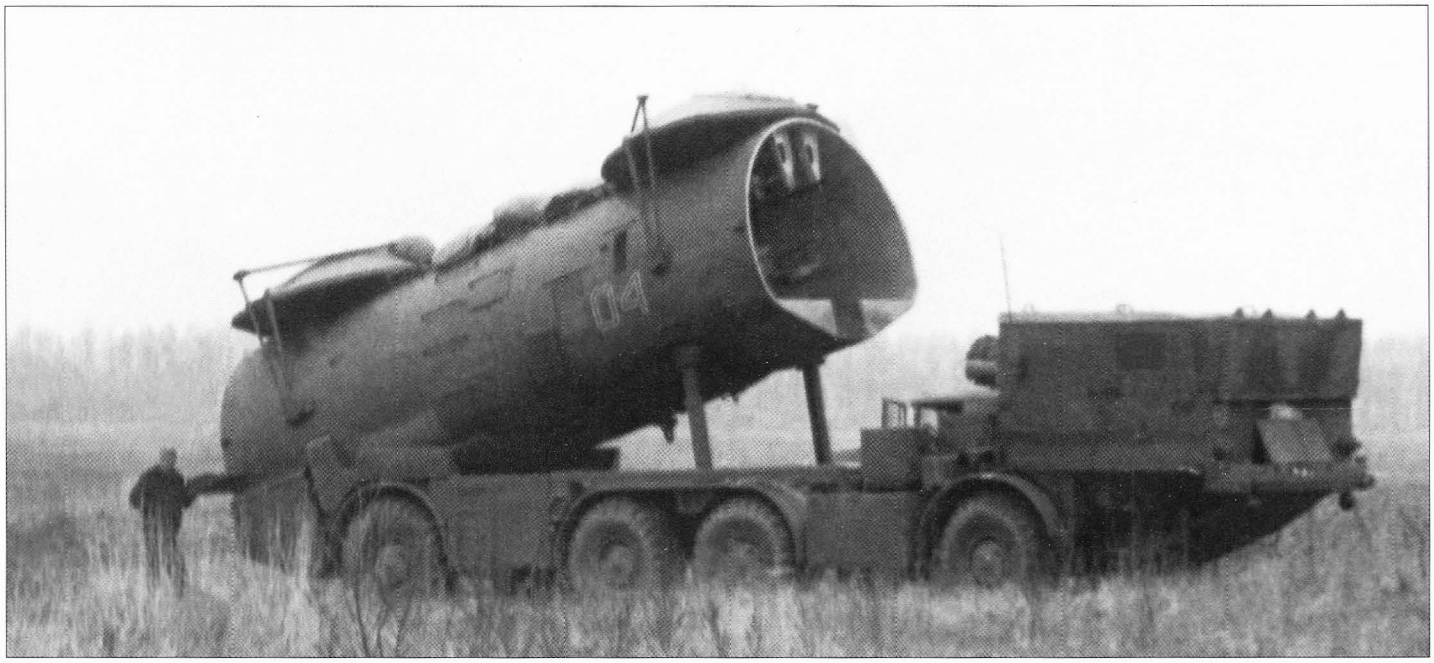


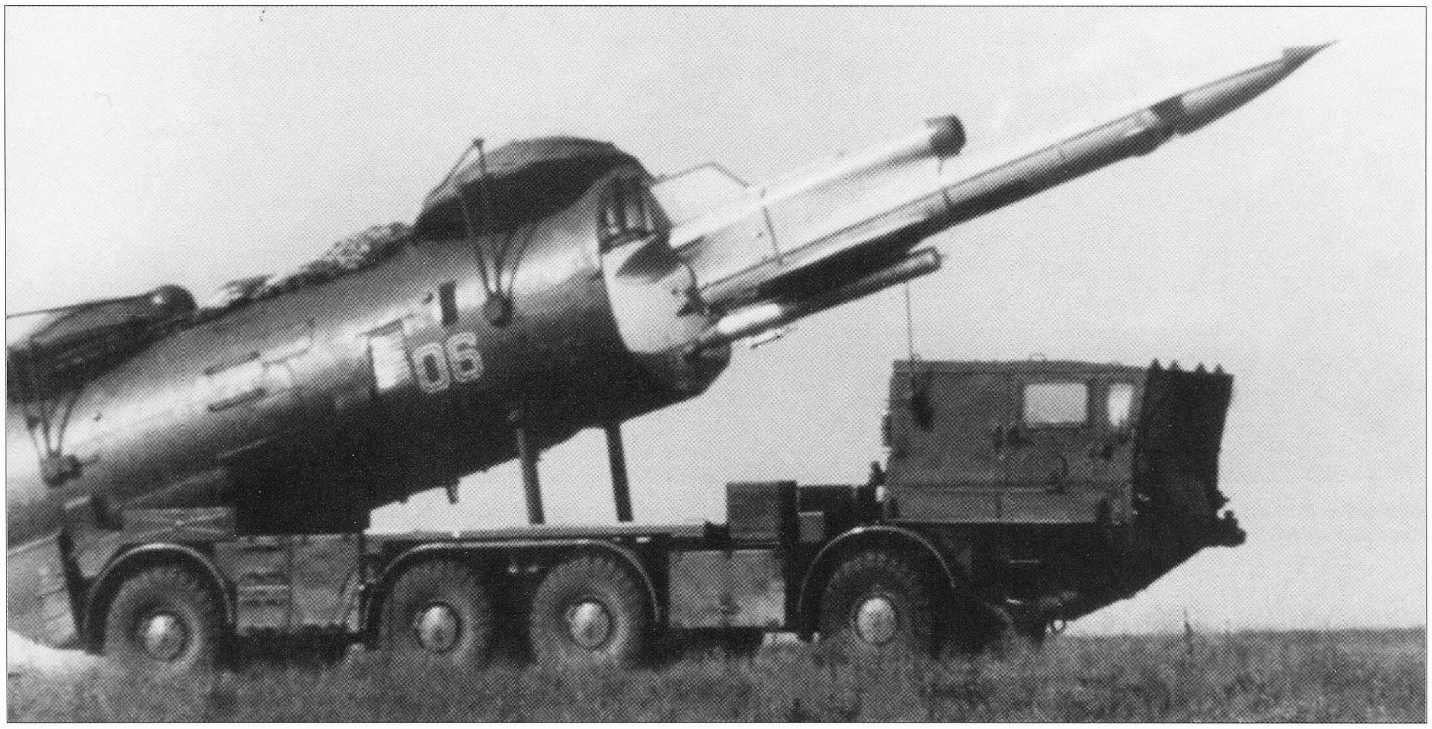
Above: A '143' is loaded onto a TZM-143 TLV during the salvage operation; note the special cargo handling beam attached to the drone. The cargo platform features tie-down fixtures, and the ones that fit under the nose are elevated. The brake parachute fairing above the nozzle is gone – compare to the photos on page 49.

Below: An SPU-143 stands in an open field with the launch tube covers open and the tube raised into position for launch. Note that a special hinged metal shield normally resting on the cab roof has been lowered into position and secured over the windshield to protect it (and the personnel inside the cab) from the blast of the rocket booster. Note also the code '04 Red' on the launch tube supplementing the regular military number plates.

Top right and centre right: The Tu-143 pops out of the launch tube of the SPU-143 like a jack-in-the-box; you need a real fast camera to capture this. It spouts terrific flames as it clears the mouth of the tube. Note the camouflage netting rolled up into a bundle on top of the launch tube.

Below right: Three SPU-143s lined up at the launch position; '02 Red' lets loose with a Tu-143 while '03 Red' has just opened the covers. Of the six launchers depicted here, five are in standard olive drab finish but one ('05 Red'?) stands out, sporting a two-tone camouflage.

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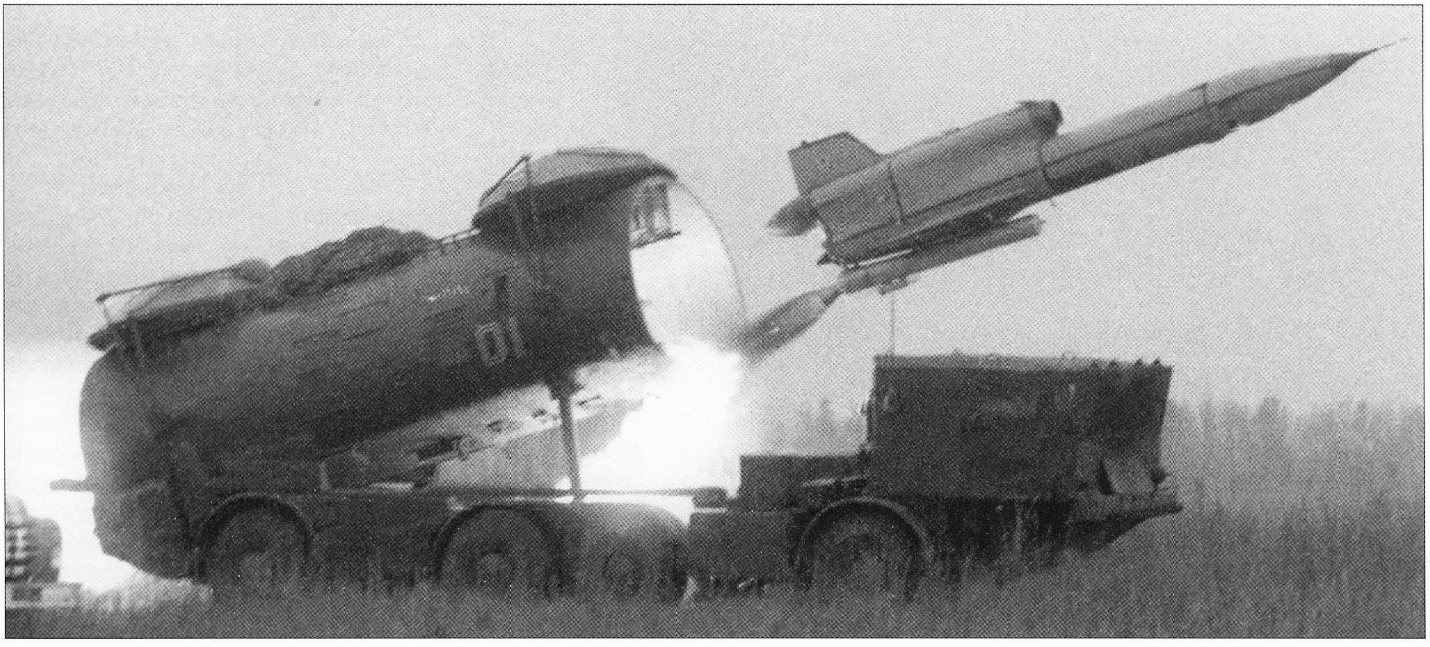
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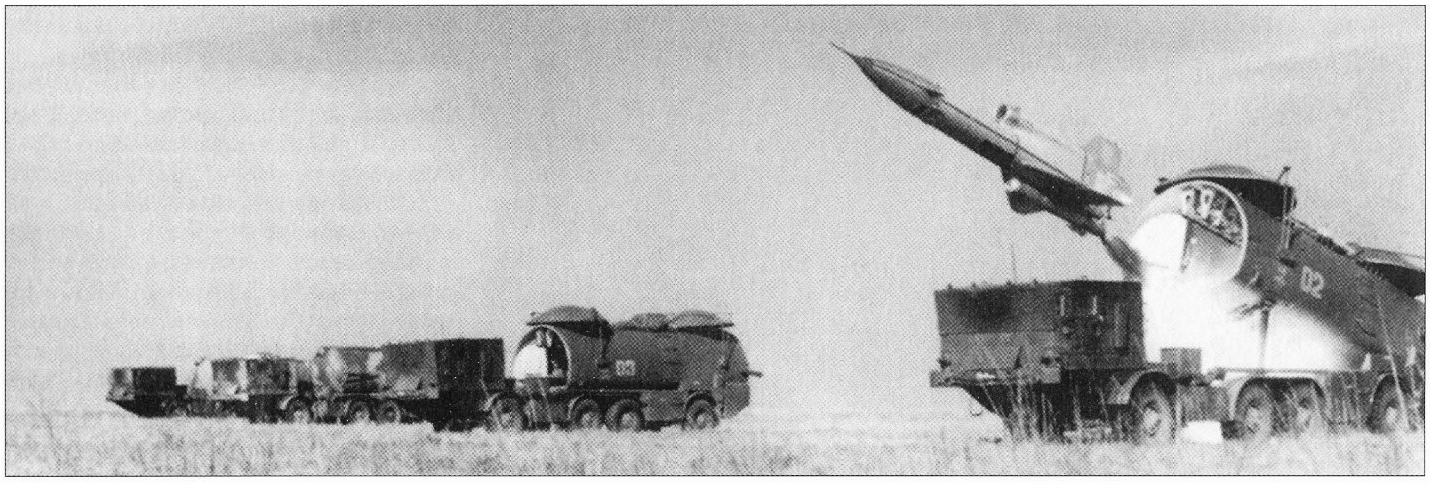
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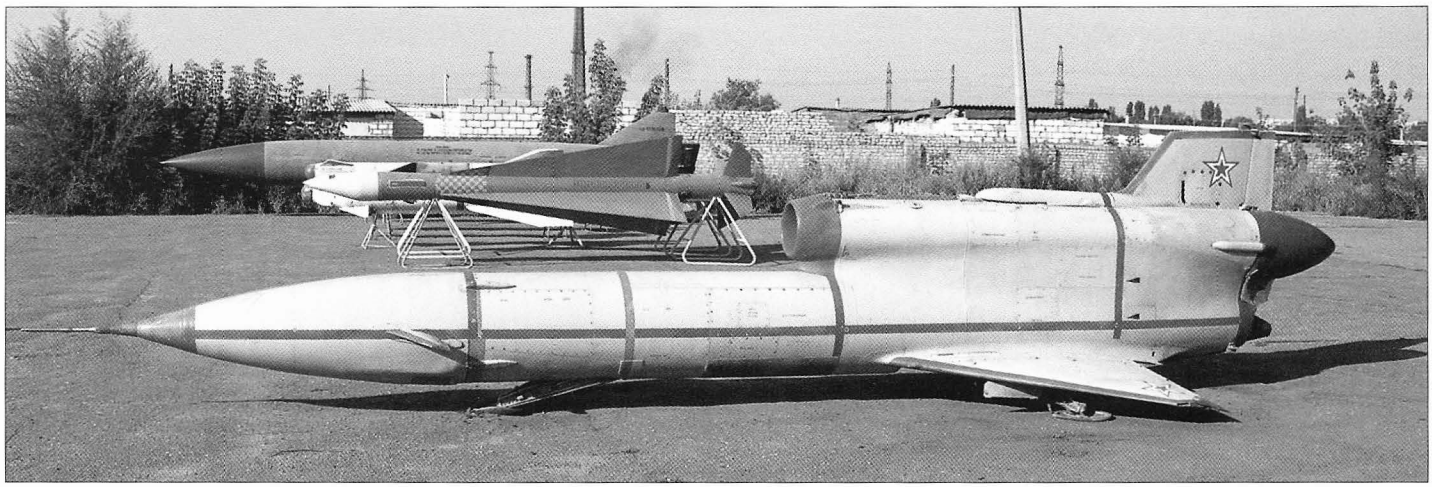
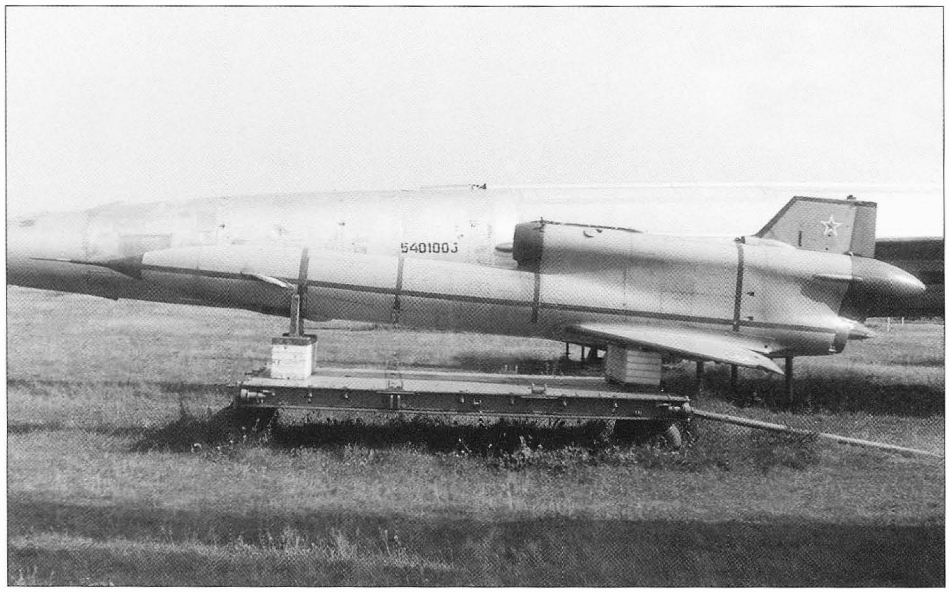


Above: This Tu-143 in TV reconnaissance configuration preserved at the GNIKI VVS Museum in Akhtoobinsk is unusual in having prominent lock fairings at the nose section/ forward fuselage joint.



Top and above: This Tu-143 was on show in the Moscow-Khodynka museum. The engine has been removed; note the non-standard parachute bay doors creating the false impression of an air intake at the fin root.

Israeli forces. The Czechoslovak Air Force took delivery of its Tu-143s in 1984, and enough were delivered to equip two squadrons. The type remained in service long enough to see the dissolution of Czechoslovakia, one squadron each being retained by the Czech Republic and Slovakia.

A production Tu-143 in high-visibility Day-glo red markings was preserved in the open-air museum at Moscow-Khodynka since early 1995. Two identically painted examples (on a TZM-143 TLV and on a ground handling dolly) were on display at the MAKS-95 airshow at Zhukovskiy on 22nd-27th August 1995.

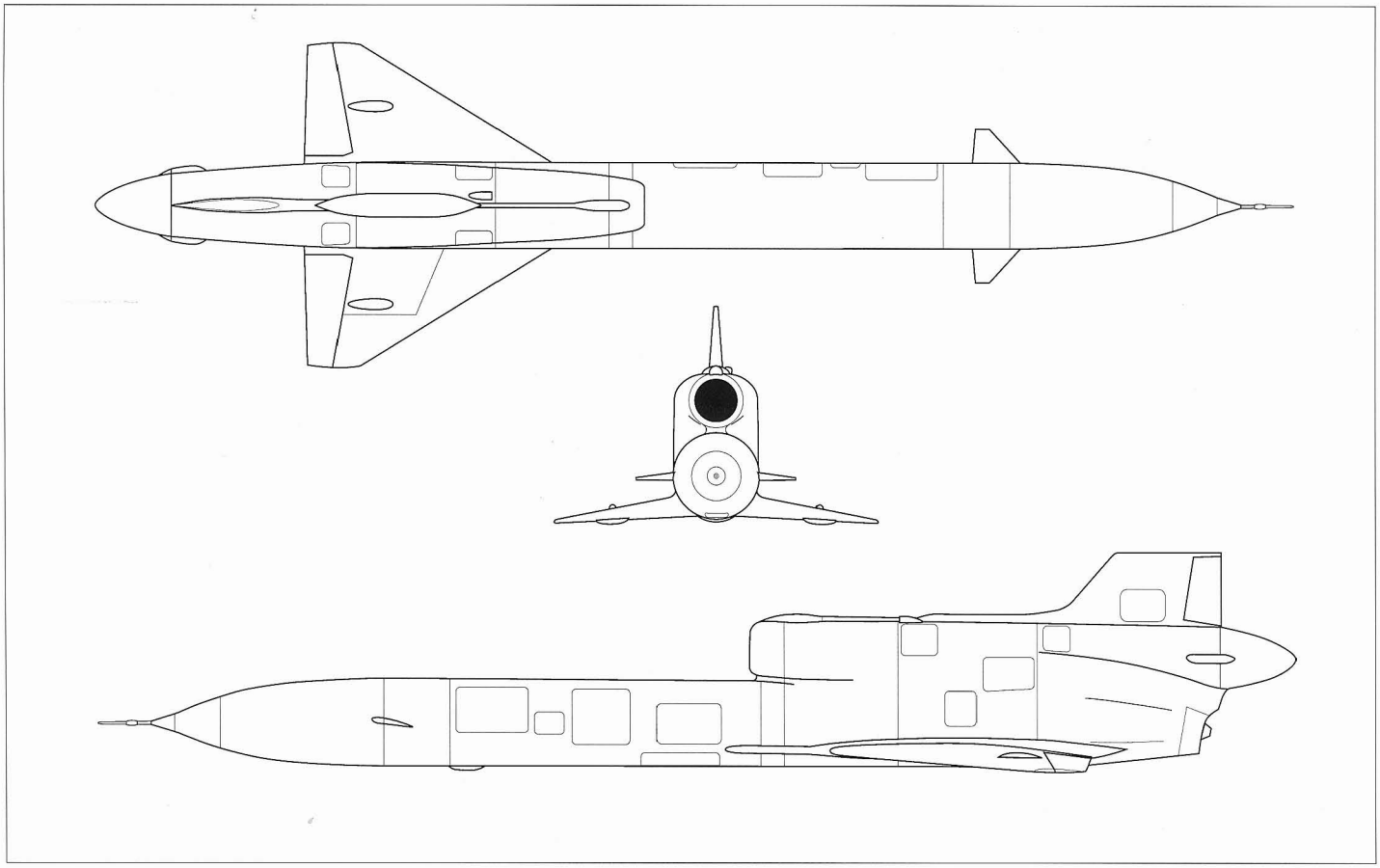
The '143' (Tu-143) in detail

Type: Subsonic reconnaissance drone utilising a canard layout. The airframe is mostly of riveted metal construction and is largely made of D16 series duralumin alloys. Some structural elements are made of AMG-6 magnesium alloy; glassfibre reinforced plastic (GRP) honeycomb structures are also used.

Fuselage: Semi-monocoque stressed-skin structure. The fuselage cross-section changes from circular in the forward fuselage to oval with the longer axis vertical in the centre/rear fuselage.

Structurally the fuselage is divided into four sections: the nose section (Section F1), the forward fuselage (Section F2), the centre fuselage (Section F3) and the rear fuselage (Section F4). The *nose section* (frames 0-3) is the reconnaissance equipment bay fairing – a detachable module whose shape differs according to the mission equipment fit. It is a GRP shell of honeycomb construction incorporating camera ports.

The reconnaissance equipment is mounted on a cantilever truss attached to Section F2, to which Section F1 is attached by bolts around the perimeter of frame 3; its forward portion rests on the front end of the truss. Section F1 can be detached and stored separately.



A three-view of the Tu-143 in RINT configuration.

The *forward fuselage* (frames 3-9) serves as an avionics/equipment bay housing control system modules and electric equipment.

The *centre fuselage* (frames 9-14) features the air intake. Its forward part accommodates the fuel tank (through which the S-shaped inlet duct passes), the fuel pump, the fuel accumulator, the G load protection device ensuring stable engine operation during manoeuvres and the hydraulic pump. The lower portion of Section F3 houses the rear aerial of the radio altimeter and Doppler speed/drift sensor (enclosed by a flush dielectric panel) and the electric power distribution panel. Located low on the starboard side are two AERTP-78 sockets for connecting test equipment during pre-flight checks and scheduled maintenance.The upper portion features an air intake fairing, the parachute suspension system and parachute release locks. The lower rear portion houses an adapter manufactured integrally with the engine's oil tank, which connects the engine's intake assembly to the inlet duct.

The *rear fuselage* (aft of frame 14) incorporates the engine bay accommodating the cruise engine and its accessories. Located above the engine jetpipe is a parachute recovery system housing with clamshell doors; it also carries the vertical tail. A lateral cooling air scoop is provided for the starter-generator. The jettisonable parabolic GRP tailcone forming an extension of the air intake fairing houses the brake parachute, the main parachute and retro-rocket are housed further forward. A special fairing underneath the tailcone (which is jettisoned together with it) encloses the pyrotechnically actuated parachute release locks.

Wings and empennage: Cantilever low-wing monoplane with cropped-delta wings. Leading-edge sweep 58°, small negative trailing-edge sweep, slight anhedral from roots. The wings are one-piece structures attached to the centre fuselage. They have full-span one-piece elevons.

Small fixed delta canard foreplanes with strong incidence are mounted on the nose section, their lift providing adequate longitudinal stability. A short trapezoidal fin and rudder assembly with low aspect ratio and 40° leading-edge sweep is installed atop the parachute recovery system housing.

Landing gear: Retractable tricycle type; all three units are equipped with dished pads which lie flush against the aircraft's skin when retracted to minimise drag. The nose unit retracts forward into Section F2, the main units outward into the wings; the landing gear is retracted at all times except during the second stage of the landing when the drone descends vertically.

A two-stage parachute/retro-rocket recovery system ensuring a smooth touchdown is provided. The ignition of the retro-rocket is triggered by impact probes extending downward from the wings concurrently with the landing gear. The parachute and retro-rocket are jettisoned automatically at touchdown.

Powerplant: One Izotov (NPP Klimov) TR3-117 non-afterburning axial-flow turbojet rated at 590-640 kgp (1,300-1,410 lbst). The engine is a derivative of the TV3-117MT turboshaft powering several Soviet helicopter types; it differs from the original model in having a long straight jetpipe instead of a two-stage free turbine and an angled jetpipe and in having electric, not pneumatic starting.

The TR3-117 is a single-spool turbojet with a 12-stage axial compressor, an annular combustion chamber with 12 flame tubes, a two-stage axial turbine and a fixed-area subsonic nozzle. The first five compressor stages feature variable inlet guide vanes; two anti-surge bleed valves are installed aft of the seventh compressor stage. The air intake assembly has a fixed spinner and four radial struts. The engine has a dorsally-mounted accessory gearbox. Starting is by means of a GS-12TOM starter-generator connected to the gearbox.

The engine has a self-contained control system and an oil system; the latter uses B-3V synthetic oil which permits starting at ambient temperatures down to –40°C (–40°F). A fire extinguishing system is provided.

The engine breathes through a dorsal fixed-area subsonic air intake with an S-duct. This arrangement, together with the aircraft's small size and the use of composites, serves to reduce its RCS.

An SPRD-251 solid-fuel rocket booster is attached under the rear fuselage by means of a centreline fitting at the front and two rear fittings flanking the cruise engine nozzle. It is jettisoned after burnout.

Control system: ABSU-143 automatic flight control system (see also Avionics and equipment) stabilising the aircraft around its CG and enabling automatic flight along a pre-programmed route; it also operates the mission equipment and the parachute recovery system. The rudder and elevons are controlled by hydraulic actuators receiving control inputs from three RM-100 control servos (RM = *roole**va**ya ma**shin**a*).

Fuel system: An integral tank in the centre fuselage holds 190 litres (41.8 Imp gal) of fuel.

Hydraulic system: The hydraulic system has a Model 465P electric pump. It operates the control surface actuators and is used for emergency landing gear extension.

Electric system: Main 27 V DC power is supplied by a 12-kW engine-driven GS-12TOM starter-generator with an RN-180M voltage regulator. Backup 24 V DC power is provided by a 20STsS-3 lead/zinc battery housed in the forward fuselage equipment bay. AC power for the AFCS and the mission equipment is supplied by a 750-VA PO-750 single-phase AC converter (*preobrazo**vah**tel' odno**fahz**nyy*) and a 200-VA PT-200Ts three-phase AC converters (*preobrazo**vah**tel' tryokh**fahz**nyy*).

Avionics and equipment:

Navigation and piloting equipment: The ABSU-143 AFCS comprises an AP-143 autopilot, a DISS-7 Doppler speed/drift sensor system (***dop**lerovskiy izmer**it**el' **sko**rosti i **snos**a*), a V-143 computer (V = *vychis**lit**el'*), an A-032 low-range radio altimeter and a BVV-1 altitude data entry module (*blok **vvod**a vyso**ty***).

The forward portion of the forward fuselage avionics bay houses the computer, the radio altimeter and the DC battery. The autopilot is a monobloc unit mounted on a frame at the rear of the bay which could be slid out for maintenance. The DISS-7 and the forward aerial of the radio altimeter were installed at the bottom of the bay, together with an AC converter and electric connection buses,

Mission equipment: In PHOTINT configuration the Tu-143 is fitted with a PA-1 panoramic camera (*pano**rahm**nyy **aero**fo**toappa**raht***) with a 120-m (393-ft) roll of film. The intervals between exposures are set automatically, depending on the flight altitude.

The TV reconnaissance version is equipped with an I-429B ***Chib**is-B* (Lapwing-B) TV system featuring a data link component for relaying the image to the intelligence processing unit. The picture is accompanied by range marker signals generated by the AFCS to indicate the drone's position.

The RINT configuration features Sigma-R radiometric equipment and a data link component.

Basic specifications of the '143' (Tu-143) reconnaissance drone and the VR-3 (Reys) aerial reconnaissance system

Length overall	8.06 m (26 ft 5²¹⁄₆₄ in)
Height (fuselage axis level) less rocket booster	1.545 m (5 ft 0⁵⁵⁄₆₄ in)
Wing span	2.24 m (7 ft 4⅛ in)
Wing area, m² (sq ft)	2.9 (31.18)
Launch weight (with booster), kg (lb)	1,230 (2,710)
Landing weight, kg (lb)	1,012 (2,230)
Cruising speed, km/h (mph)	875-950 (543-590)
Maximum launch altitude above sea level, m (ft):	2,000 (6,560)
Flight altitude, m (ft):	
on PHOTINT missions	200-1,000 (660-3,280)
on TV reconnaissance missions	300-1,000 (990-3,280)
Area being photographed, in relation to the flight altitude (H):	
width	10 x H
length	220 x H
Width of area being reconnoitred (TV reconnaissance)	2.2 x H
Width of area being reconnoitred (RINT)	2 x H
Number of turns on the flight trajectory	2
Range, km (miles)	170-180 (105-111)
Endurance, minutes	13
Reconnaissance radius, km (miles)	70-80 (37.3-43.5)
The system's relocation range with a ready-to-launch drone, km (miles)	up to 500 (310)
The system's road speed on paved roads, km/h (mph):	
day	45 (28)
night	30 (18.6)
Deployment time on arrival at the site, minutes	15
Preparation time for a repeat sortie, hours	4
Maximum number of launches	5

M-143 (VR-3VM) target drone

A radio-controlled target drone version of the '143' designated M-143 (or VR-3VM, the M standing for *mi**shen'***) appeared in 1985. The tests gave good results; the drone could successfully emulate various classes of aircraft.

'143' psychological warfare drone project

An interesting version of the '143' reconnaissance drone intended for psychological warfare operations (psy-ops) was under development in the late 1970s and early 1980s. The nose section housing reconnaissance equipment was replaced by a new forward fuselage accommodating eleven bundles of propaganda flyers with a total weight of 19 kg (41.8 lb) and a mechanism for disseminating them. The leaflets could be dropped through the module's three ventral hatches simultaneously or consecutively; the drop sequence was initiated by the AFCS in accordance with the programme entered before the flight. So far the psy-ops version remains in project form.

VR-3D (Reys-D) tactical unmanned aerial reconnaissance system:

'243' (Tu-243) tactical reconnaissance drone

In the late 1970s the need arose to upgrade the existing VR-3 (Reys) tactical unmanned aerial reconnaissance system in order to enhance its combat efficiency. The customer demanded the installation of new reconnaissance equipment having higher resolution and enabling night operations. Another requirement concerned improvement of flight performance, notably range. Finally, there was a requirement to reduce the number of personnel and support equipment associated with the system and generally simplify operational procedures.

On 6th March 1981 the Council of Ministers issued directive No.249-76 ordering development of the upgraded VR-3D (Reys-D) tactical unmanned aerial reconnaissance system; the D stood for ***dahl'niy*** – long-range. The Ministry of Defence took nearly two years to work out the SOR for the upgraded system, endorsing this document in February 1983.

Design work on the VR-3D system and prototype construction continued until 1987. At the Tupolev OKB the upgraded reconnaissance drone was designated '243' (Tu-243). Thus, for once, the OKB appears to have adopted the time-honoured Czech tradition of adding 100 to an aircraft's designation after a more or less extensive redesign; cf. Avia B-34/B-234/B-534, Aero 45S/Super Aero 145, Zlin Z-26/Z-126/-Z-226/Z-326/Z-526 and so on.

Retaining the predecessor's basic airframe structure, powerplant and systems, the '243' featured an all-new mission equipment suite and a new navigation/flight control suite. The designers also changed the placement of some avionics and equipment items to free up space for extra fuel.

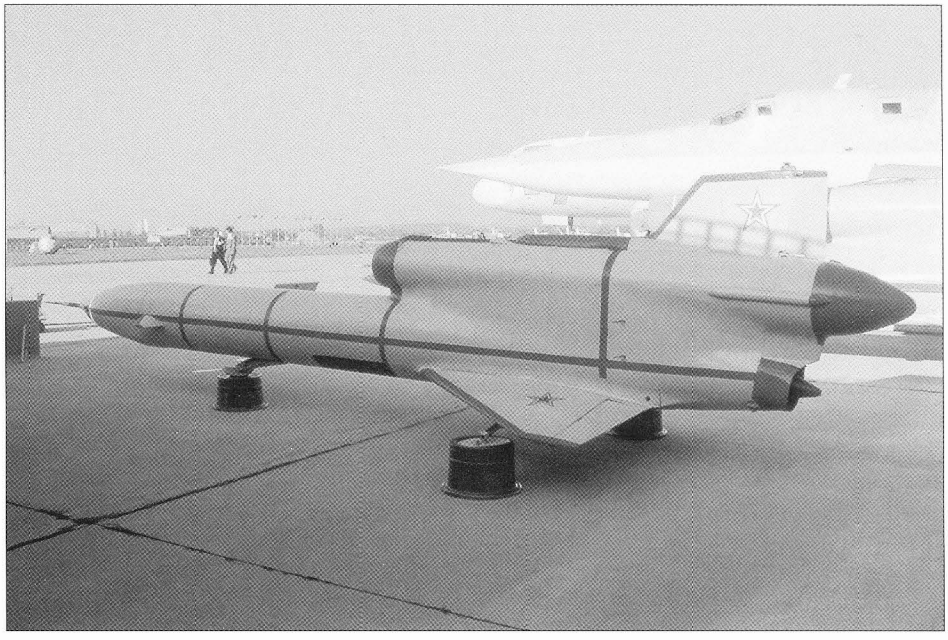
The '243' reconnaissance drone prototype entered flight test in July 1987. When a development batch of drones had completed the state acceptance trials programme, the VR-3D system entered full-scale production, superseding the original VR-3 on the assembly lines at Kumertau.

The VR-3D (Reys-D) has civil applications as well as military ones. It is intended for:

- reconnoitring enemy troop and combat vehicle concentrations;
- reconnoitring fortifications and other structures;
- damage assessment the in the wake of natural disasters and man-made ecological disasters;
- detecting forest fires and assessing their size;
- detecting leaks on oil and gas pipelines.

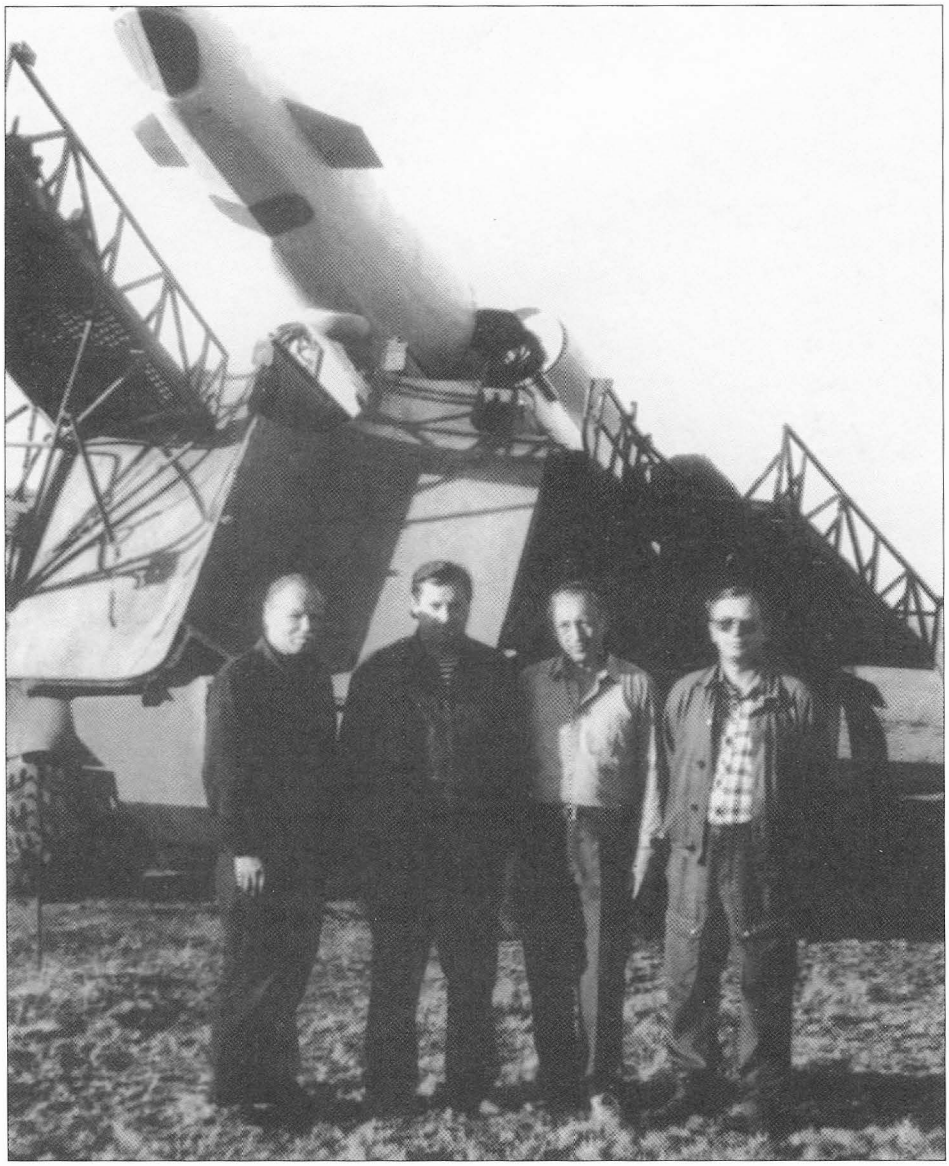
Two alternative reconnaissance equipment fits were available, allowing missions to be flown around the clock. The first version comprised an AP-402 panoramic camera and an Aïst-M (Stork-M, pronounced ***ah****-ist*) TV reconnaissance system with real-time data transmission via a Trassa-M (Route-M, or Road-M) data link system. In the second version the TV reconnaissance system was replaced by a Zima-M (Winter-M) thermal imager coupled with the same Trassa-M data link system. As a back-up, the imagery generated by the optoelectronic systems was recorded by an on-board data storage module. Together with the drone's improved flight performance this more capable mission equipment suite allowed the Reys-D system to reconnoitre up to 2,100 km² (810.8 sq miles) in a single sortie. The '243' could also be fitted with Sigma-R radiometric equipment.

Above and below: This Tu-243 was in the static park of the MAKS-95 airshow at Zhukovskiy.



Basic specifications of the '243' (Tu-243) reconnaissance drone and the VR-3D (Reys-D) aerial reconnaissance system

Length overall	8.29 m (27 ft 2⅜ in)
Height (fuselage axis level) less rocket booster	1.576 m (5 ft 2¾ in)
Wing span	2.25 m (7 ft 4³⁷⁄₆₄ in)
Wing area, m² (sq ft)	2.9 (31.18)
Launch weight (with booster), kg (lb)	1,400 (3,090)
Cruising speed, km/h (mph)	850-940 (528-583)
Maximum launch altitude above sea level, m (ft):	2,000 (6,560)
Flight altitude, m (ft)	50-5,000 (164-16,400)
Range, km (miles)	360 (223)
Maximum number of launches	10



Khar'kov aircraft factory personnel pose in front of an SPU-141 launcher during the tests of the '141'.

The '243' (Tu-243) had a new NPK-243 navigation/flight control suite (*navigatsi**on**no-pilot**azh**nyy **kom**pleks*) utilising state-of-the-art electronic components, which enhanced the system's capabilities considerably. A radio beacon designated Marker was fitted to facilitate the search and recovery operation after the drone had landed.

The predecessor's SPRD-251 solid-fuel rocket booster was replaced by a new RDTT-243 booster (*ra**ket**nyy **dvig**atel' tverdo-**top**livnyy* – solid-fuel rocket motor) which was both lighter and more powerful, delivering a maximum impulse of 14,820 kgp (32,670 lbst). The cruise engine was also updated, being a TR3-117A incorporating measures aimed at enhancing reliability.

The ground part of the system was upgraded accordingly, comprising the SPU-243 mobile launcher, the TZM-243 TLV (which is outwardly identical to the SPU-143, except for the shape of the launch tube's front and rear covers), the KPK-243 checkout and test suite, the POD-3D intelligence reception, processing and transmission unit and so on. This facilitated the operation of the VR-3D considerably. All together, the new features that went into the VR-3D (Reys-D) system increased its combat potential more than 2.5 times as compared to the VR-3 (Reys).

VR-2 (Strizh-1) theatre/tactical unmanned aerial recce system:

'141' (Tu-141) theatre/tactical reconnaissance drone

Almost concurrently with the VR-3 system the Tupolev OKB started work on the VR-2 theatre/tactical unmanned aerial reconnaissance system, alias Strizh (Swift, the bird), intended for operations over enemy-held territory up to several hundred kilometres beyond the FLOT. The pilotless aircraft forming the core of the system was designated '141' (Tu-141).

The '141' was originally conceived as a two-mode reconnaissance drone that was to fly at subsonic speeds most of the time, accelerating to 1,200-1,300 km/h (745-807 mph) twice during the sortie for a transonic dash during air defence penetration on the way out and on the way home. This, and the requirement that the drone should land horizontally on a retractable centreline skid, was what the Air Force demanded. However, preliminary calculations made by the OKB showed that, if the performance target was to be met, this approach would incur a substantial weight penalty. Also, providing transonic capability called for a complex variable air intake design and a much more powerful engine than for a purely subsonic aircraft (possibly an afterburning turbojet); this would entail an increase in fuel capacity and hence a further increase in all-up weight.

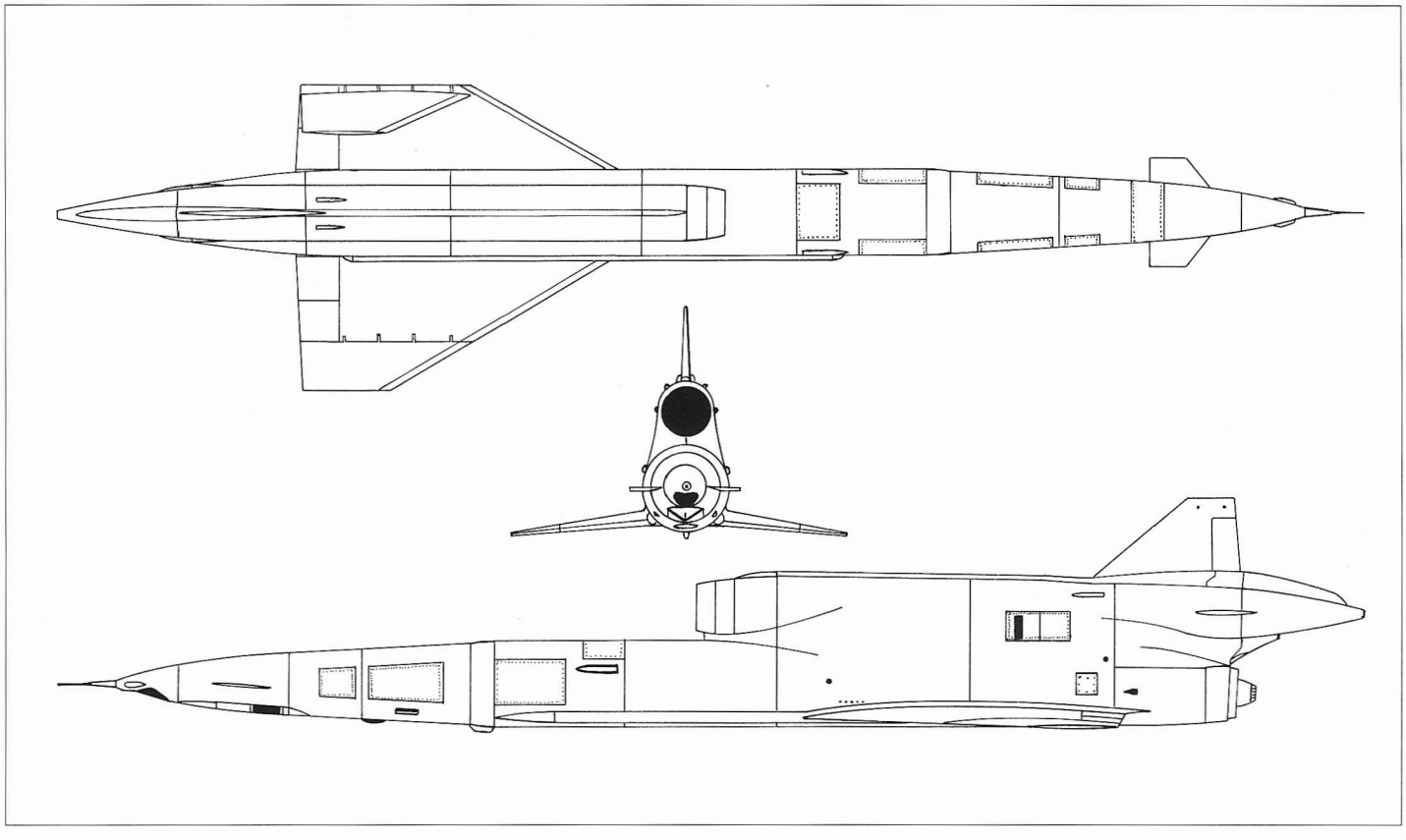
Therefore the Tupolev OKB decided the VR-2 could do without transonic capability, limiting the drone's speed to about 1,000 km/h (620 mph) over the entire route. The proposed horizontal landing arrangement was also scrapped in favour of a parachute/retro-rocket recovery system. Gradually the projected '141' drone began to look more and more like a scaled-up version of the '143'. The ultimate version of the VR-2 (Strizh) system was similar in its architecture and ideology to the VR-3 (Reys), differing in having a larger aircraft with a wider spectrum of mission equipment and a new ground support equipment suite.

From an aerodynamic and structural design standpoint the '141' was a scaled-up version of the '143'. The selection of cameras and the thermal imager available for installation in the '141' allowed the drone to fly reconnaissance missions round the clock and a long way from the launch site. Laser reconnaissance systems and RINT systems were also considered.

The '141' (Tu-141) took off from an SPU-141 mobile launcher, a special semi-trailer towed by a KrAZ-260V 6x6 tractor unit. The attending vehicles and equipment also included the TZM-141 TLV, the KPK-141 checkout and test suite, the POD-3 intelligence reception, processing and transmission unit and the MT-141 field maintenance shop. The system was capable of rapidly redeploying over large distances while retaining adequate combat capability. To facilitate transportation by road on the TZM-141 the drone's wingtips folded vertically upwards, reducing the span.

The prototype of the '141' (Tu-141) made its first flight in December 1974; like the subsequent prototypes, it was powered by a KR-17A short-life turbojet. Production commenced in 1979 at aircraft factory No.135 named after the Lenin Young Communist League in Khar'kov, the Ukraine (now called

Above: The SPU-141 is disengaged from the tractor unit and lowered into position as shown to create the necessary launch attitude. Note the integral V-shaped blast shield and the power/control cables on the left. An ATs-40-131 fire engine based on the ZiL-131 stands by in case things get out of hand.



A three-view of an early PHOTINT version of the '141' (Tu-141). The port wing is shown in folded position in the upper view.

Top and above: The launch of the Tu-141 is an impressive sight, as the drone creates an almighty dust cloud and leaves a huge plume of smoke and flame. The ZiL-131 with a van body sealed against NBC contaminants is either a KPK-141 test equipment van or an MT-141 maintenance shop.

Below: A Ukrainian Air Force Tu-141 (note the shield-and-trident insignia) at the landing site after a test flight. The personnel swarming around the aircraft include a TV cameraman.

Below right: Objective completed. A Tu-141 descends on its recovery parachute. It really makes you marvel that such a huge parachute is packed into such a small space.

Khar'kov State Aircraft Manufacturing Co.); a total of 152 were built, including the Moscow-built prototypes. Since the intended engine was unavailable in production form at the time, the initial production batch of ten Tu-141s was manufactured with identically rated Tumanskiy R9A-300 turbojets (a derivative of the Mikulin RD-9B); all subsequent examples had KR-17As.

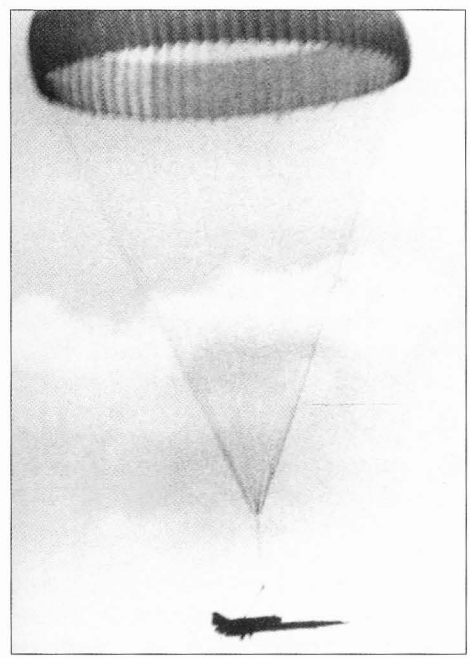
Upon completion of the manufacturer's flight tests and the state acceptance trials the VR-2 (Strizh-1) theatre/tactical unmanned aerial reconnaissance system officially became part of the Soviet Army inventory. Most of these systems were stationed along the Soviet Union's western borders; many of them were taken over by the newly-formed CIS republics (notably the Ukraine) after the collapse of the USSR. A show held at Sknilov airbase near L'vov on 22nd August 1992 to celebrate the first anniversary of the Ukraine's independence featured a Tu-141 wearing an early version of the newly-adopted Ukrainian Air Force insignia on the wings and tail instead of the hitherto customary red stars. This was not the type's only show appearance; a Tu-141 in pure PHOTINT configuration and high-visibility Dayglo red markings was displayed at the MAKS-95 airshow complete with its SPU-141 launcher. It was there again at the MAKS-97 airshow (19th-24th August 1997).

A Tu-141 coded '05 Yellow' (falsely labelled as an M-141 target drone) is preserved at the Central Russian Air Force Museum in Monino. Another example coded '12 Yellow' on an SPU-141 launcher was on display at Moscow-Khodynka. A third Tu-141 ('14 Yellow') is in the Khar'kov State Aircraft Manufacturing Co. museum at Khar'kov-Sokol'nikovo airfield.

The '141' (Tu-141) in detail

Type: Subsonic reconnaissance drone utilising a canard layout. The airframe is mostly of riveted metal construction and is largely made of D16 series duralumin alloys.

Fuselage: Semi-monocoque stressed-skin structure. The fuselage cross-section changes from circular in the forward fuselage, with a maximum diameter of 950 mm (3 ft 1$^{13}/_{32}$ in), to oval with the longer axis vertical in the centre/rear fuselage.



Structurally the fuselage is divided into four sections: the nose section (Section F1), the forward fuselage (Section F2), the centre fuselage (Section F3) and the rear fuselage (Section F4). Sections F1 and F2 house the reconnaissance equipment, avionics and electric equipment. The shape of Section F1 differs according to the mission equipment fit, featuring either an ogival GRP nosecone (in this case there is a single ventral camera port with V-shaped glazing) or a metal nose fairing incorporating a second (forward-looking) camera port. In the former case an L-shaped pitot is mounted dorsally on the dielectric radome; in the other version the pitot is straight and mounted at the tip of the nose. Sections F3 and F4 accommodate three fuel tanks, the engine and various aircraft systems (notably the parachute/retro-rocket recovery system whose brake parachute fairing is located above the engine nozzle).

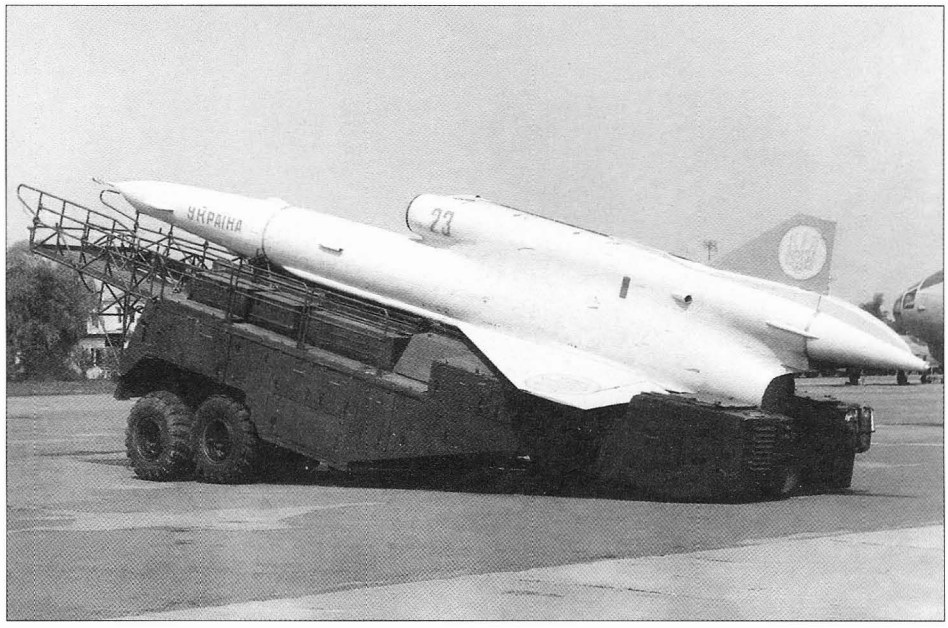
Wings and empennage: Cantilever low-wing monoplane with cropped-delta wings. Leading-edge sweep 58°, trailing-edge sweep –3°, slight anhedral from roots. The wings are two-piece structures attached to the centre fuselage. The inboard portions are fitted with two-section elevons; the smaller outer wing panels fold upward for storage and travel by road on a TLV.

Small trapezoidal canard foreplanes are mounted on the forward fuselage, their lift providing adequate longitudinal stability; leading-edge sweep 41°20', trailing-edge sweep –1°30'. Their incidence is ground-adjustable from 0° to 8°, depending on the CG position. A short trapezoidal fin and rudder assembly with 40° leading-edge sweep folding to port for storage is installed atop the parachute recovery system housing.

Landing gear: Retractable tricycle type; all three units are equipped with dished pads. The nose unit retracts forward into Section F2, the main units inward into the wings; the landing gear is retracted at all times except during the second stage of the landing when the drone descends vertically.

A two-stage parachute/retro-rocket recovery system ensuring a smooth touchdown is provided. The ignition of the retro-rocket is triggered by impact probes extending downward from the wings concurrently with the landing gear. The parachute and retro-rocket are jettisoned automatically at touchdown.

Powerplant: One KR-17A (or, on the first ten production aircraft, R9A-300) non-afterburning axial-flow turbojet rated at 2,000 kgp (4,410 lbst). The engine is installed nose-up at 4°30' to the fuselage waterline and breathes through a dorsal fixed-area subsonic air intake with an S-duct.



Above: Tu-141 '23 Blue' wearing Ukrainian Air Force markings and the legend *Ookraïna* (The Ukraine) was displayed at L'vov-Sknilov on 22nd August 1992. The UAF insignia are an interim version.

'52 Blue', another UAF Tu-141 with the definitive shield-and-trident tail insignia, at Kiev-Svyatoshino during the Aviasvit-XXI airshow in September 2000, with a KrAZ-260V tractor unit (number plate 4493 K8) standing alongside. The maintenance platforms at the rear and the guardrails fold out of the way before launch.

A powerful solid-fuel rocket booster is attached under the rear fuselage by means of a centreline fitting at the front and two rear fittings flanking the cruise engine nozzle. It is jettisoned after burnout.

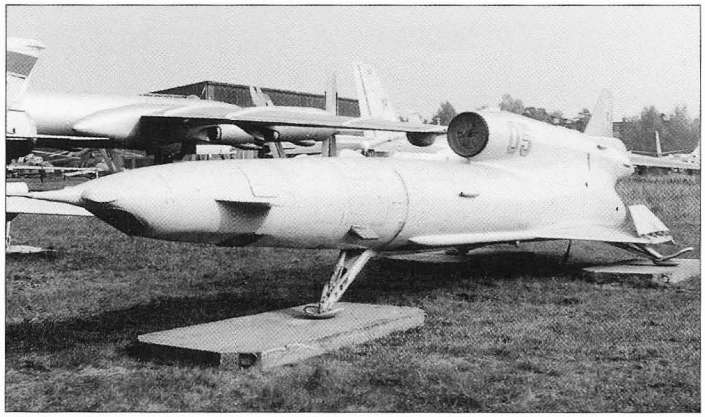
Control system: Automatic flight control system (see also Avionics and equipment) stabilising the aircraft around its CG and enabling automatic flight along a pre-programmed route; it also operates the mission equipment and the parachute recovery system. The rudder and elevons are controlled by hydraulic actuators.

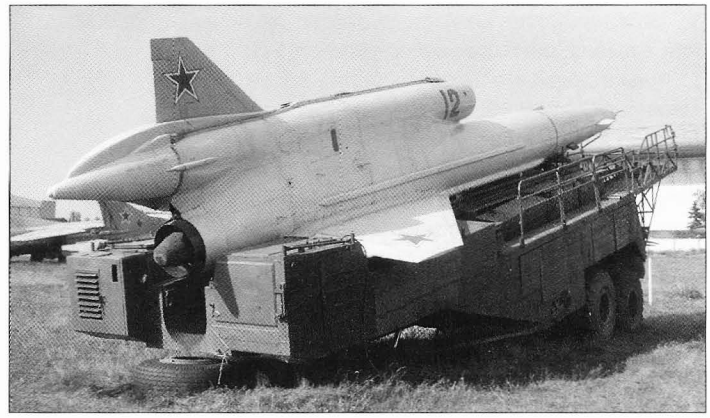
Avionics and equipment:
Navigation & piloting equipment: AP-141 autopilot, DISS-7 Doppler speed/drift sensor system, VU-141 computer, A-032 low-range radio altimeter, RSBN-141 short-range radio navigation system (***rah**diotekh**nich**eskaya sis**tem**a **blizh**-ney navi**gah**tsii* – SHORAN), A-720 and so on.

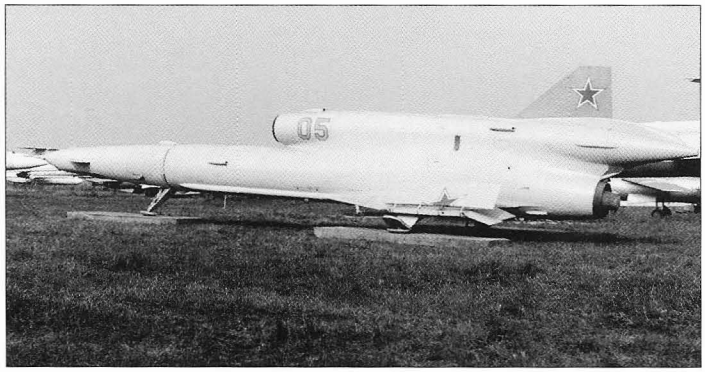
Mission equipment: PA-4 panoramic camera, A-86P forward-looking oblique camera and other equipment.

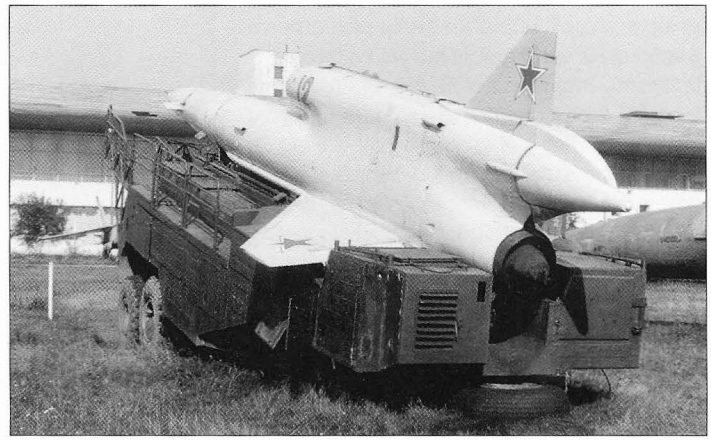
M-141 target drone

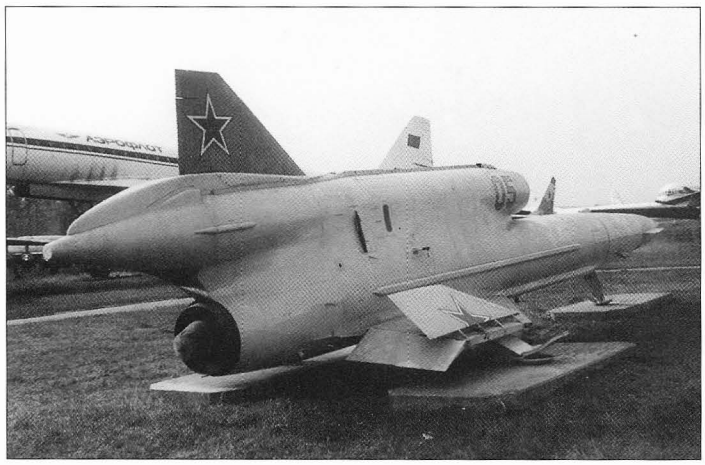
A radio-controlled target drone version of the '141' designated M-141 was developed. The drone was tested but did not enter production.

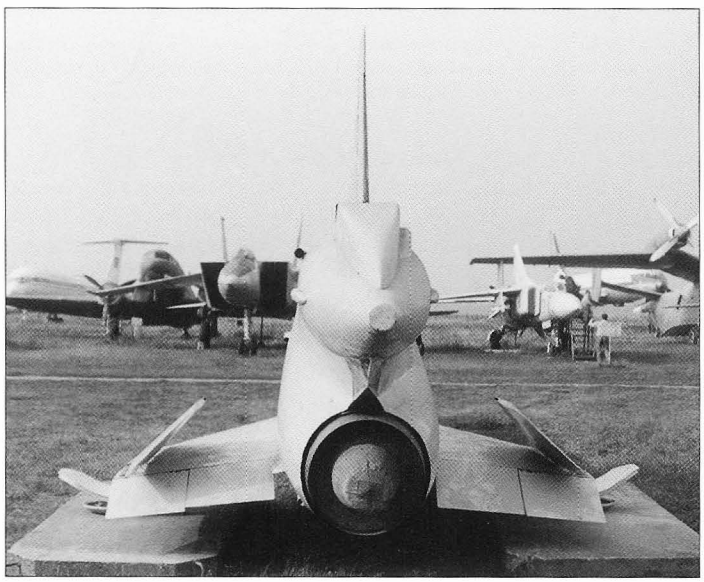


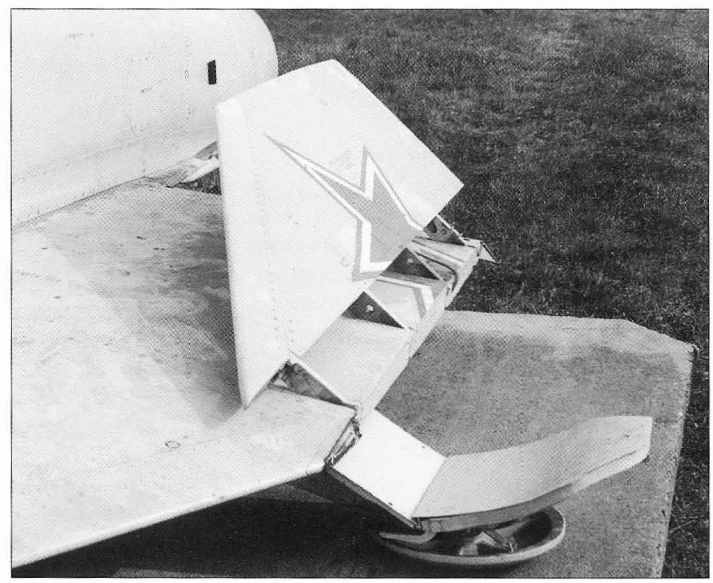


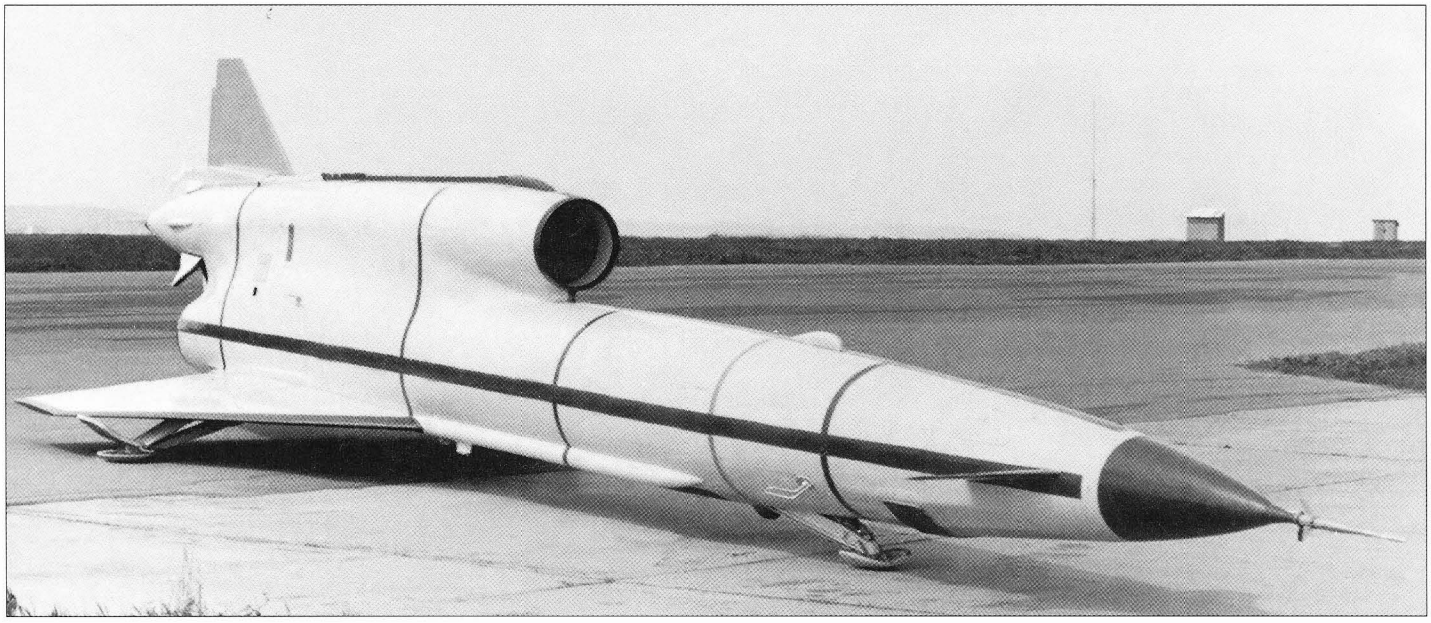












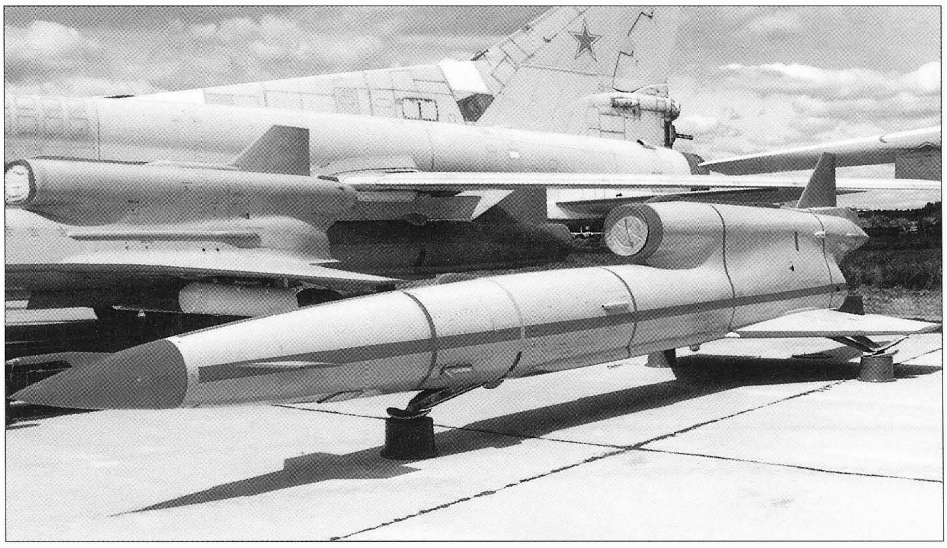
Opposite page, left-hand column: The Central Russian Air Force Museum in Monino obtained this early 'chisel nose' Tu-141, '05 Yellow', in 1993. The data placard in front of the aircraft identifies it as an (or rather *the*) M-141 target drone, but the camera ports indicate otherwise. When first put on display, the Tu-141 had the wings folded as shown here.

Opposite page, top, above & centre right: Tu-141 '12 Yellow' was displayed in the museum at Moscow-Khodynka. Note the trough in the SPU-141 launcher accommodating the rocket booster.

Opposite page, bottom right: Close-up of the wing folding joint and the port main gear unit.

This page, above: A late version of the Tu-141 features an ogival radome supplanting the oblique camera. This is the prototype featuring L-shaped telemetry aerials and no national insignia.

Right: A red-starred late Tu-141 at the MAKS-95.



Voron supersonic parasite reconnaissance drone project

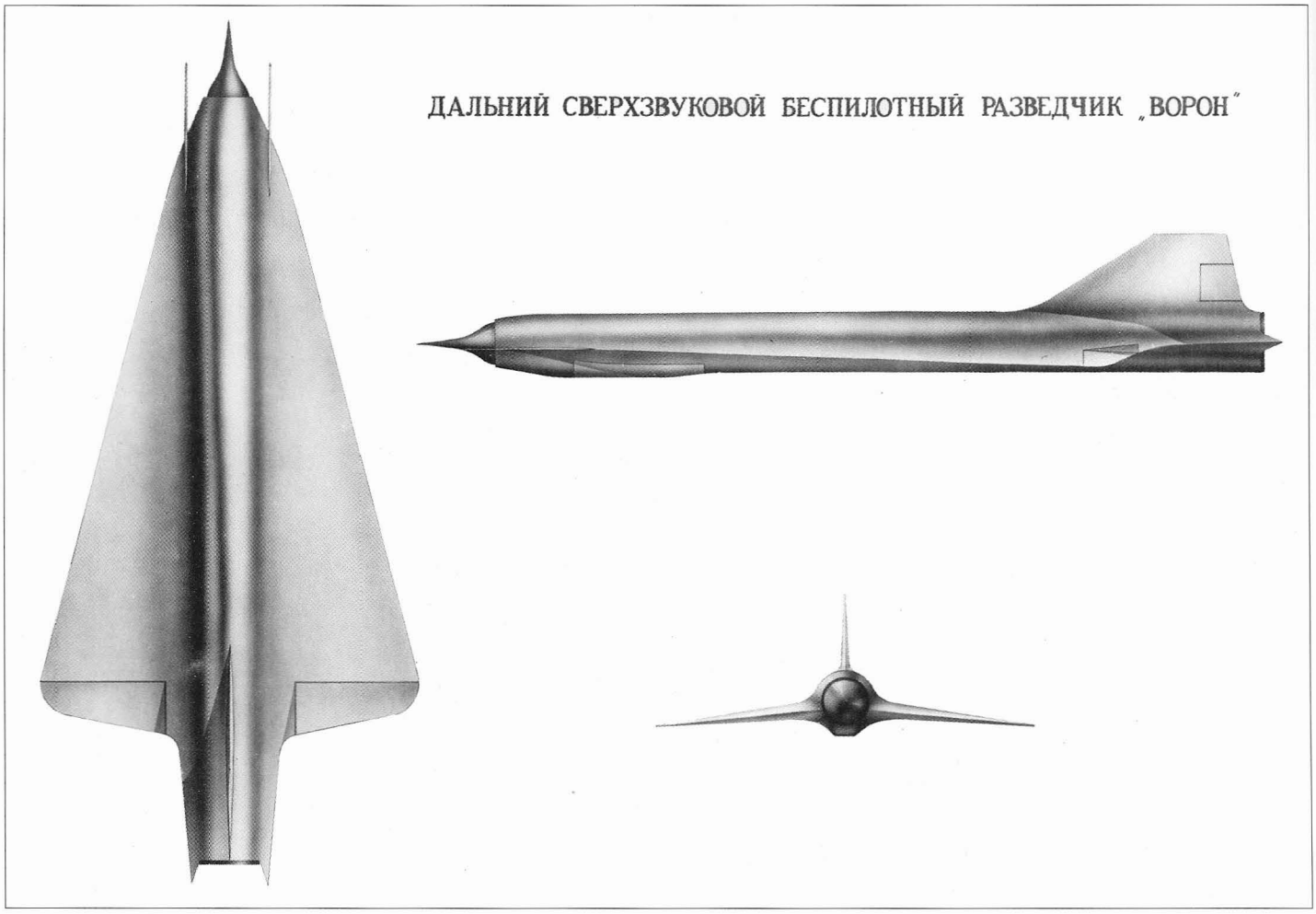
In 1968 or 1969 one of the 38 Lockheed D-21 (GTD-21B) supersonic reconnaissance drones fell into Soviet hands, courtesy of one of the Soviet Union's South-East Asian allies. This aerial vehicle shared certain design features with the famous Lockheed SR-71 Blackbird Mach 3 reconnaissance aircraft; in fact, it looked like a scaled-down SR-71 engine nacelle with wings.

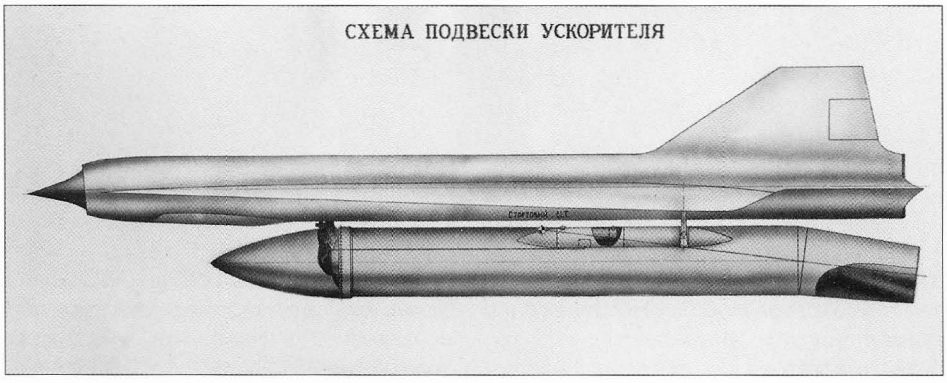
Though badly damaged (it was disposable, ejecting a film capsule for retrieval before crashing), the D-21 proved of great interest to the Soviet aircraft industry, as it was a fairly compact machine with up-to-date reconnaissance equipment. The airframe was made of titanium, being designed for prolonged reconnaissance flights at high supersonic speeds under conditions of strong kinetic heating. Many leading enterprises and organisations of the Soviet aircraft, electronics and defence industries were commissioned to study the design of the D-21, its structural materials, production technology and mission equipment. These enterprises included the Tupolev OKB which headed the study programme, as it possessed considerable experience in designing ground-launched subsonic reconnaissance drones.

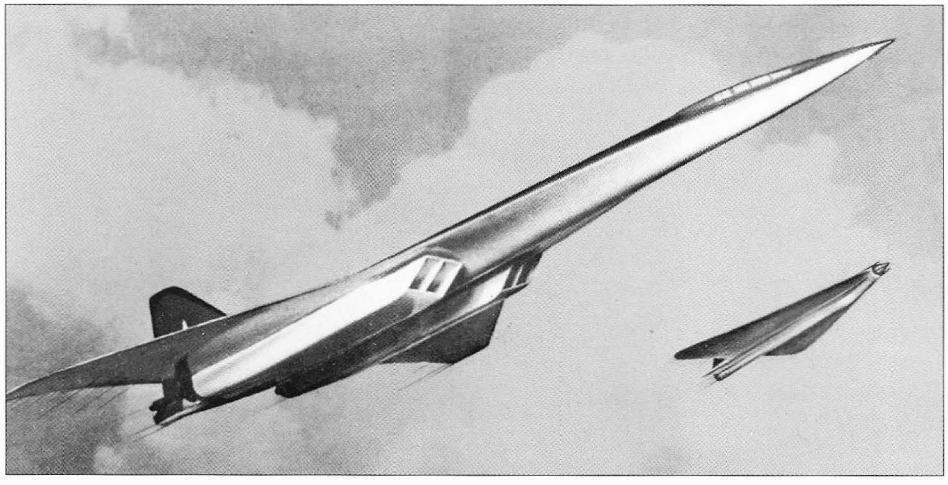
In accordance with ruling No.57 passed by the CofM Presidium's Commission on defence industry matters (VPK – *Voyen*no-*promysh*lennaya *komis*siya) on 19th March 1971 the Tupolev OKB prepared a project based on the American design but utilising a Soviet engine, indigenous materials and equipment. The programme was named ***Vor****on* (Raven); no numeric OKB designation is known. The name obviously derives from the fact that the D-21 was black as a raven's wing, being coated with special heat-dissipating paint.

Basic specifications of the '141' (Tu-141) reconnaissance drone

Length overall	14.33 m (47 ft 0 11/64 in)
Height (fuselage axis level) less rocket booster	2.435 m (7 ft 11 5/64 in)
Wing span	3.875 m (12 ft 8 3/16 in)
Wing area, m^2 (sq ft)	10.0 (107.5)
Launch weight (with booster), kg (lb)	5,370 (11,840)
Cruising speed, km/h (mph)	1,100 (683)
Flight altitude, m (ft)	50-6,000 (164-19,685)
Range, km (miles)	1,000 (620)





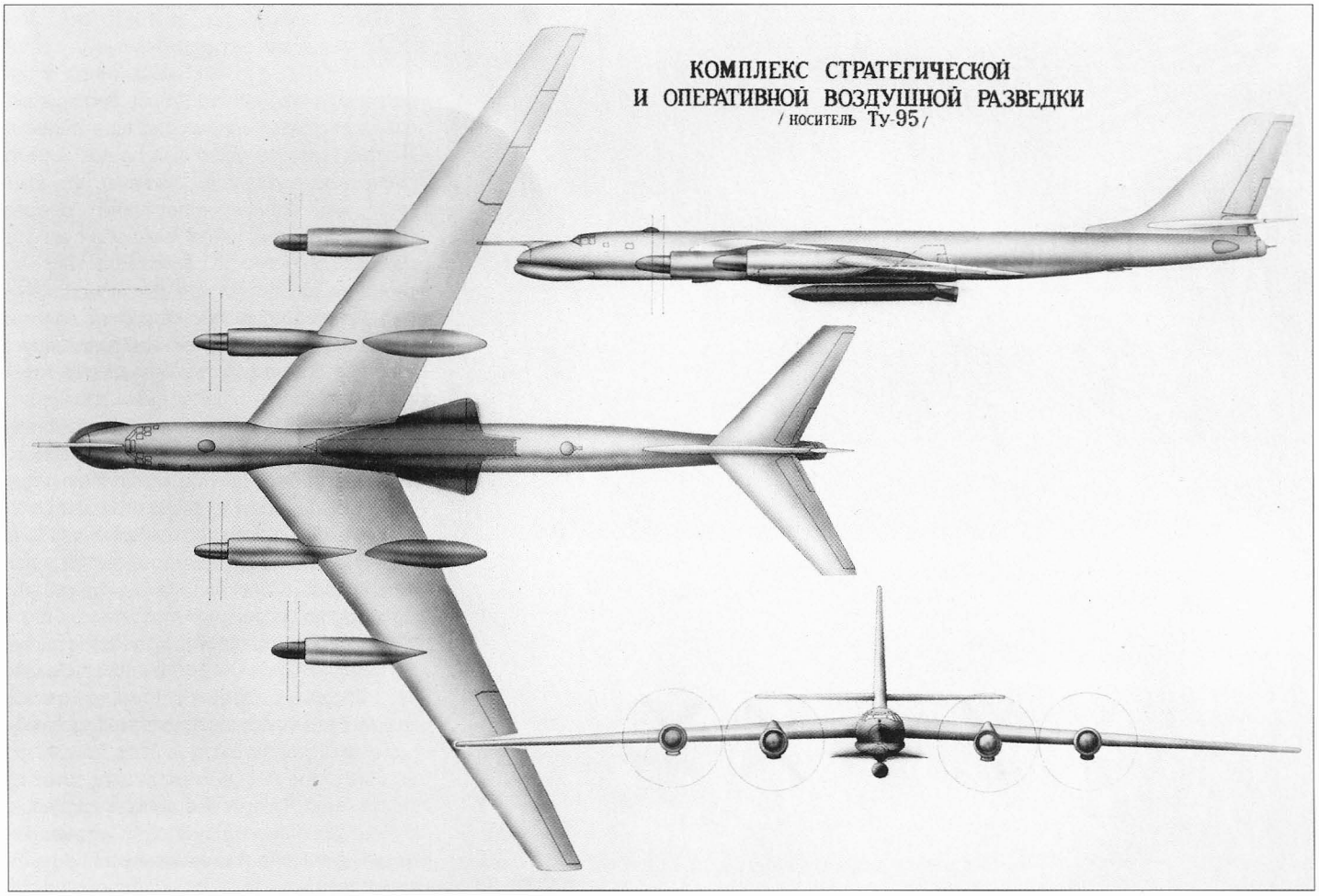


Above: A three-view drawing of the Voron from the project documents; note the ejectable camera/film capsule in the forward fuselage.

Left: The Voron was to ride a huge solid-fuel rocket booster for air launch – just like the operational D-21s which were carried aloft by modified Boeing B-52 Stratofortress bombers.

Below left: This artist's impression shows the Voron being launched by an early project version of the Tu-160 (obviously based on the Tu-144 supersonic airliner); the real Tu-160 is totally unrelated. Curiously, the artist has quite forgotten the booster.

As one might imagine, the Voron was extremely similar in appearance to the D-21 – right down to the two pitot booms flanking the air intake with its multi-shock centrebody. The main external difference lay in the shape of the wings, which were close to a pure delta planform, whereas those of the D-21 had large curved leading-edge root extensions similar in shape to the SR-71's nose chines. The engine to be used was the RD-012 supersonic ramjet with a maximum in-flight thrust of 1,350 kgp (2,980 lbst). After separation from its carrier aircraft the Voron was to be accelerated to a high supersonic speed by a solid-fuel rocket booster delivering an awesome 47,500 kgp (104,720 lbst) to activate the ramjet sustainer.



Another three-view from a Tupolev project portfolio shows the Voron as part of a theatre/strategic aerial reconnaissance system based on the Tu-95KD missile strike aircraft. Like the Kh-20 cruise missile carried by the Tu-95K/KD/KM, the drone was to be semi-recessed in the fuselage until the moment of launch.

According to the PD project, the Voron drone was to form part of a theatre/strategic reconnaissance system together with other airborne and surface facilities. The system included the drone itself, a Tu-95 or Tu-160 carrier aircraft, ground support and intelligence processing facilities. After being launched and completing its objective the drone returned to base, whereupon the recoverable section containing the intelligence data separated (as on the Yastreb-1 system).

During the research programme, a ground-launched version of the Voron was considered but thought to be less effective than the air-launched version. Work on the Voron programme went on for several years and provided a great deal of interesting and useful material for the further development of advanced hypersonic aircraft.

Reys-F tactical unmanned air strike system:

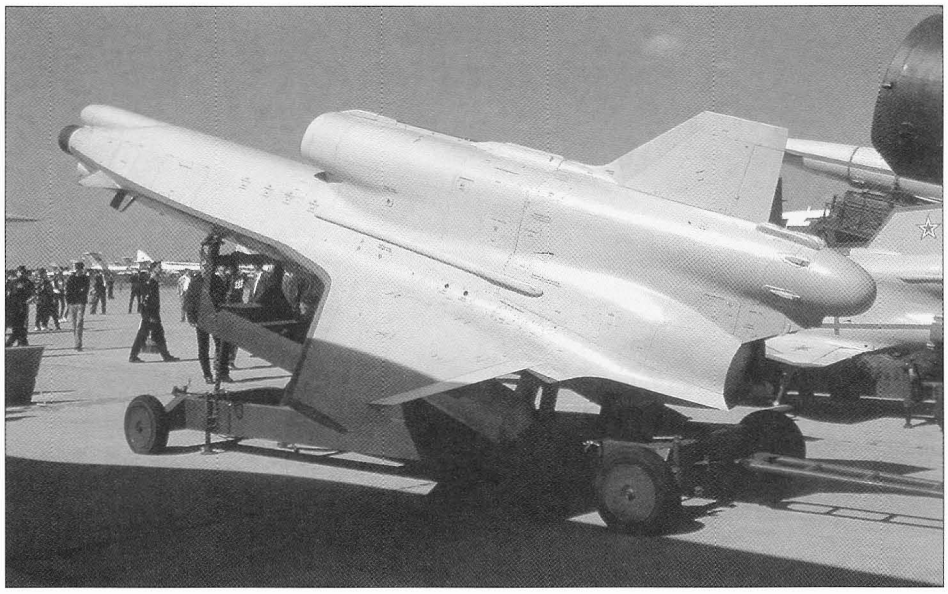
'300' (Tu-300) unmanned combat aerial vehicle

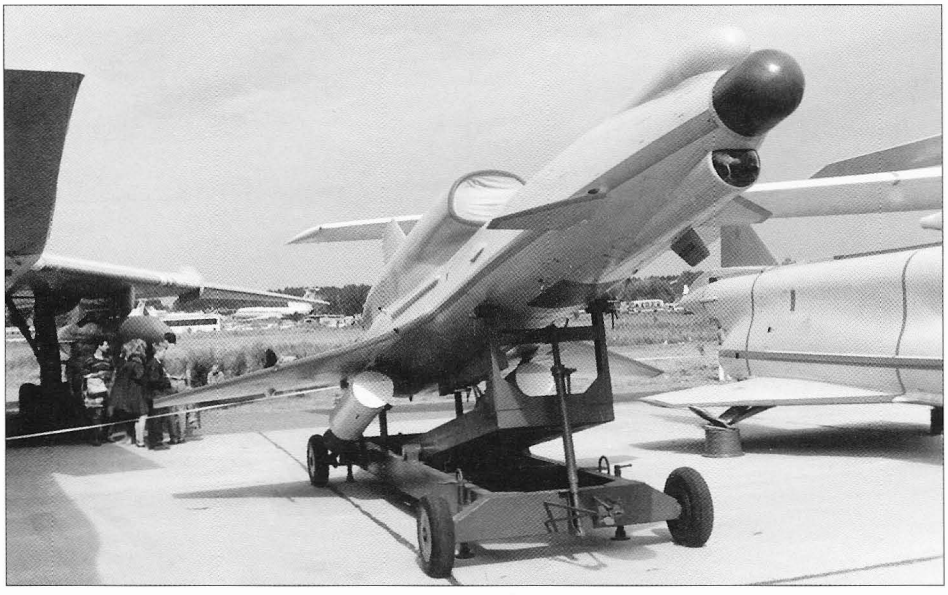
Early development work on unmanned combat aerial vehicles (UCAVs) in the Soviet Union dates back to 1982 when the OKB-51 fighter design bureau headed by Pavel Osipovich Sukhoi was instructed to start work on such a vehicle. Named ***Kor**shoon* (Kite, the bird), the Sukhoi project was to be part of a theatre/tactical strike system (see Chapter 5 for further details). After assessing the project the Ministry of Aircraft Industry decided in 1983 to transfer it to the Tupolev Aviation Scientific & Technical Complex, which had considerable experience in the field of UAV design. (This practice of 'taking away' a project and transferring it bodily to a competing OKB happened more than once in the Soviet Union – and, oddly, the Tupolev OKB was usually the beneficiary.)

At the Tupolev ASTC the project received a new designation, '300' (or Tu-300). To give credit where credit is due, the Tupolev engineers did not simply take advantage of someone else's work but chose to design the aircraft from scratch, relying on their experience with the '143' (Tu-143) and '141' (Tu-141). The result was a UCAV that had nothing in common with the original Sukhoi project except the name Korshoon.

Basic specifications of the Voron drone (as per ADP documents)

Length overall	13.06 m (42 ft 10$^{1}/_{64}$ in)
Wing span	5.8 m (19 ft 0$^{1}/_{32}$ in)
Height (fuselage axis level) less rocket booster	2.08 m (6 ft 9$^{57}/_{64}$ in)
Wing area, m² (sq ft)	37.0 (397.85)
Launch weight, kg (lb):	
without booster	6,300 kg (13,890 lb)
with booster	14,120 kg (31,130 lb)
Empty weight, kg (lb)	3,450 kg (7,605 lb)
Cruising speed in ramjet mode, km/h (mph)	3,500-3,800 (2,170-2,360)
Flight altitude, m (ft)	23,000-26,400 (75,460-86,615)
Range, km (miles)	4,600 (2,855)





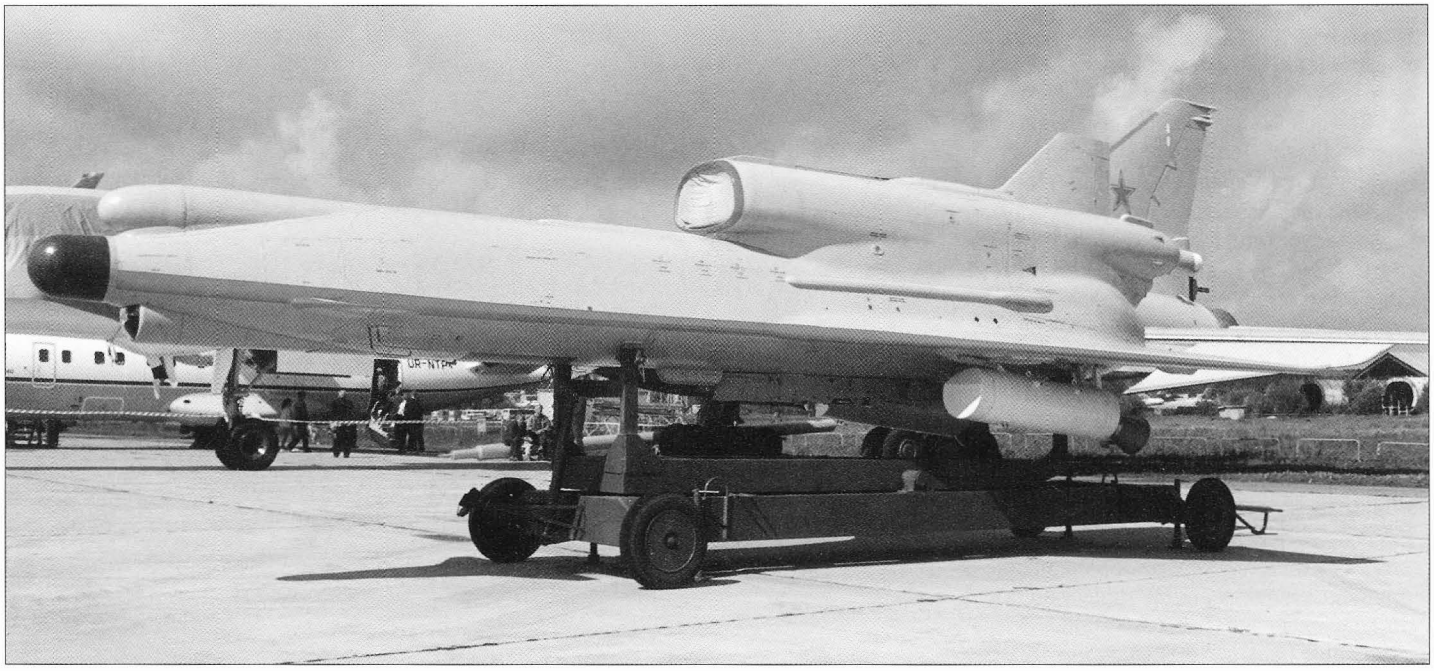
Flight tests began in 1991. The '300' UCAV shared the proven tail-first layout of the Tu-143 and Tu-141 with delta wings and a dorsal air intake with an S-duct feeding a single jet engine of undisclosed type buried in the rear fuselage which also housed a parachute recovery system. However, the fuselage was much wider and deeper, incorporating an internal weapons bay. The warload could also be carried externally on a centreline pylon, in which case it would typically be a submunitions dispenser, such as the KMGU-1 (*kon**tey**ner **ma**logaba**rit**nykh **groo**zov ooniver**sahl'**nyy* – versatile small items container).

The UCAV was launched from a sloping ramp with the assistance of two rocket boosters fitted under the wing roots, their noses being so shaped as to assist separation after burnout. The fuselage nose housed two radomes one above the other, with a transparent cupola enclosing an optoelectronic sighting system below them.

The '300' (Tu-300) was in the static park of the MAKS-95 and MAKS-97 airshows. Despite this, all design and performance details remain classified at the time of writing. Lately, however, it was revealed that the Tu-300 is to be part of the Reys-F tactical unmanned air strike system. Despite the similar designation, it has little in common with the earlier Reys/Reys-D, the F presumably standing for *fronto**voy*** (tactical).

Left and above left: The '300' (Tu-300) in the static park at the MAKS-95 airshow. The similarity to the Tu-141 and Tu-143/Tu-243 is obvious, but the internal weapons bay is not. Judging by the size of the air intake, the engine is a turbofan.

Below: The same Tu-300 at the MAKS-97 airshow.



Chapter 3

Yak 'Birds and Bees'

DPLA-60 Pchela-1 (*izdeliye* 60) tactical reconnaissance RPV

In 1982 the Soviet Ministry of Defence commissioned the development of a tactical unmanned aerial reconnaissance system to be used at the regimental level. On 12th July that year the Council of Ministers issued a directive to this effect, followed a few days later by the appropriate Ministry of Aircraft Industry, Ministry of Electronics Industry (MRP – *Mini**ster**stvo **rah**dioelek**tron**noy pro**mysh**lennosti*) and MoD orders. The MRP's *Koo**lon*** (Coulomb) Research Institute had overall responsibility for the programme, while OKB-115 headed by Aleksandr Sergeyevich Yakovlev was tasked with designing the UAV as such. Sergey Aleksandrovich Yakovlev, the General Designer's elder son, and Yuriy I. Yankevich headed the development effort.

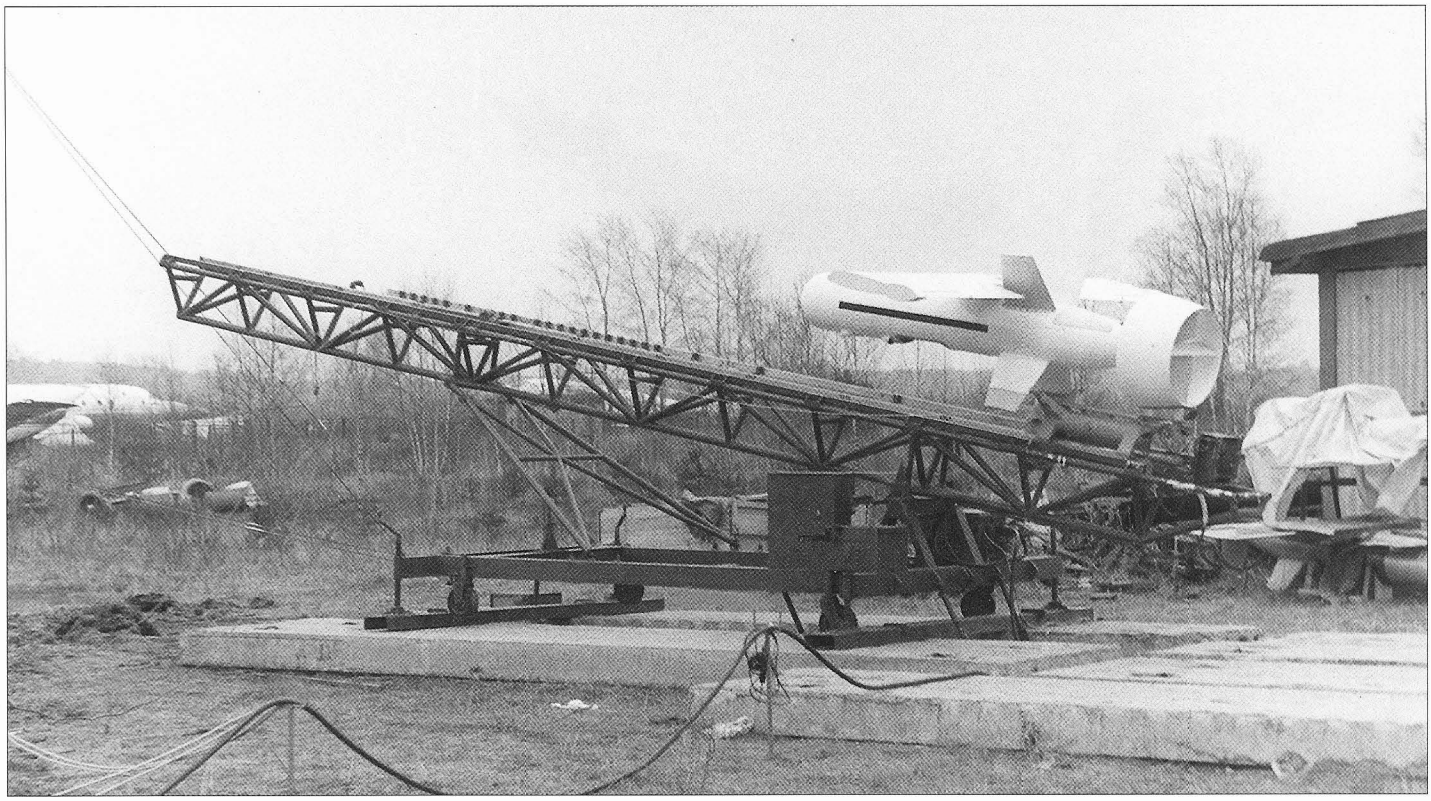
The system's prospective operator was the Soviet Airborne Troops (VDV – *Voz**doosh**no-de**sahnt**nyye voy**ska***) which needed an autonomous reconnaissance asset to support the operations of a commando or recce group inserted behind enemy lines and having virtually no outside information channels to rely on. This operational aspect accounted for some of the system's design features. Specifically, the UAV had to be as simple and cheap as possible; the system had to be air-droppable and capable of fully autonomous operation. Finally, the ground part of the system was to be based on the standard wheeled and tracked vehicles used by the VDV.

In accordance with the specifications drawn up by the three ministries the tactical unmanned aerial reconnaissance system was to feature a reusable compact remotely piloted vehicle. The deadline for the beginning of the tests was set at February 1983.

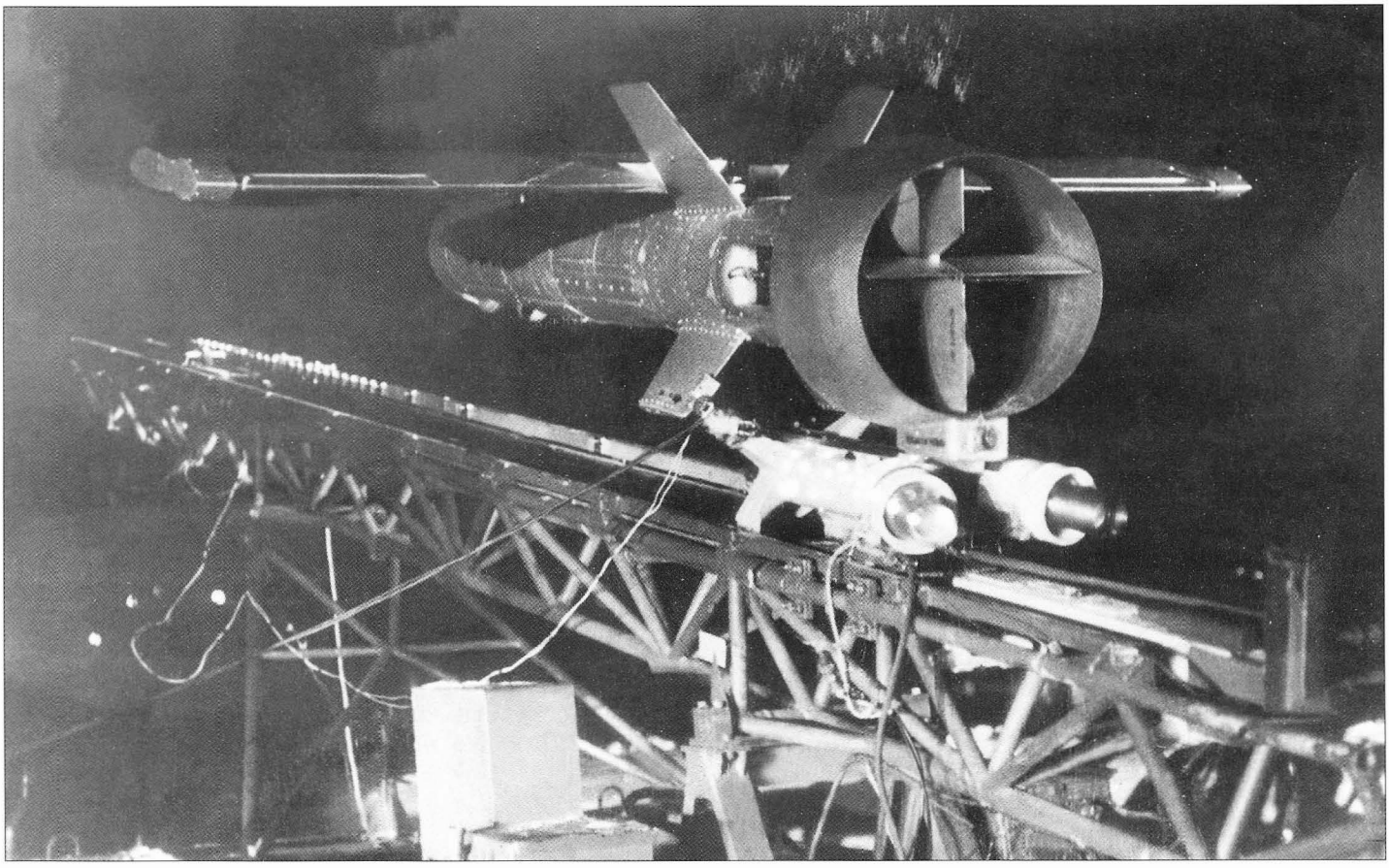
The Yakovlev OKB contemplated several alternative general arrangements, including a biplane layout. The version selected eventually featured shoulder-mounted unswept wings folding along the fuselage for storage.

Besides the aircraft itself, the system – the first of its kind in the Soviet Union – included an integrated launch/control vehicle (LCV) based on the BMD-1 paradroppable armoured fighting vehicle (*boye**va**ya ma**shin**a de**sah**nta*), a set of test equipment and an evacuation/support vehicle based on the GAZ-66 4x4 army lorry (the Soviet counterpart of the Bedford RL). The system enabled pre-launch servicing of the RPV, launch and radio-controlled flight, reception of the TV image generated by the machine and its safe recovery for further use. The RPV, which received the manufacturer's designation *izdeliye* 60, was primarily a daytime TV reconnaissance platform but could also be fitted out as an electronic countermeasures (ECM) aircraft for jamming enemy radio communications. Other designations used are DPLA-60 (*distantsi**on**no-pilo**tee**ruyemyy le**ta**tel'nyy appa**raht*** – RPV) and *Pche**la-1*** (Honeybee-1).

The *izdeliye* 60 was a high-wing monoplane with an annular empennage; the wings of rectangular planform folded forward to save space during transportation and storage. The fuselage had a modular design, being divided into a forward section housing the mission equipment, a centre section

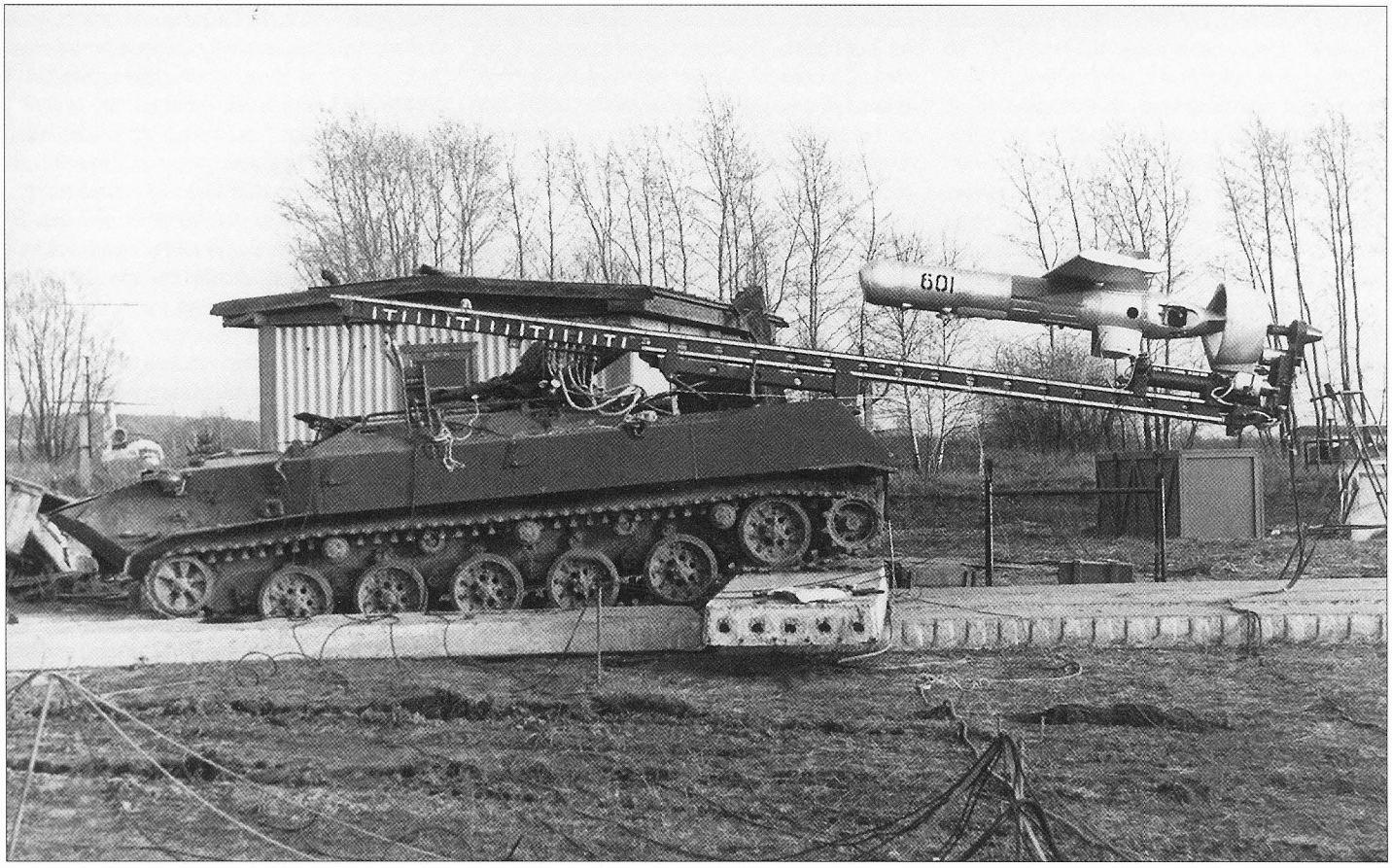


A white-painted dummy *izdeliye* 60 UAV sits on a very provisional mobile launcher during tests; the fixed cruciform stabilising fins are well visible. Note the lack of the engine cooling apertures on the rear fuselage sides and the 'solid' nose. Note also the Tu-104 avionics testbed with a MiG-31 radar nose visible on the left.

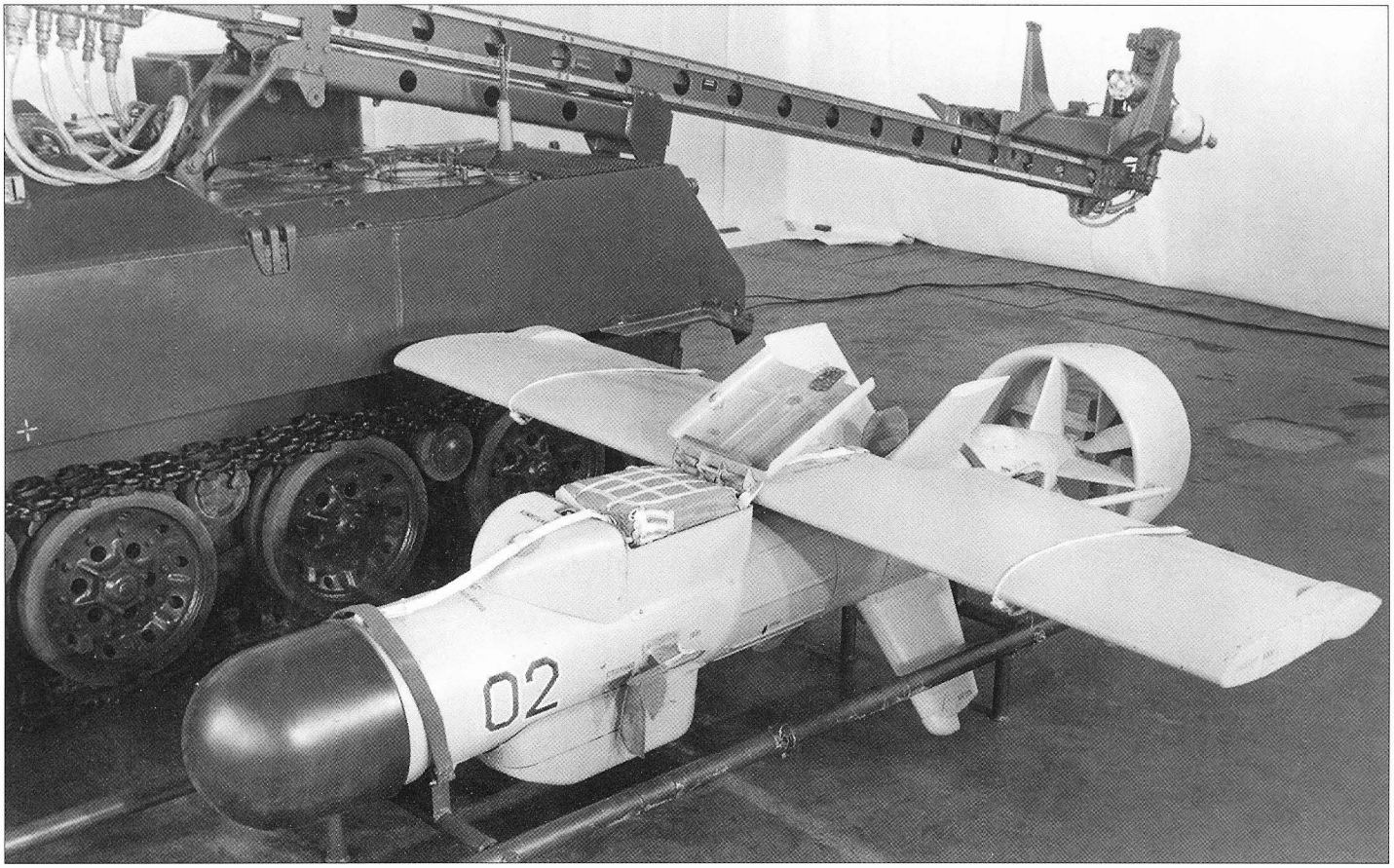


Above: The first *izdeliye* 60 (Pchela-1) prototype on the same launcher; the machine is painted silver overall and has no parachute recovery system. This shot illustrates the tail unit design with cruciform control surfaces inside the annular stabiliser/propeller duct and the launch sled with the two rocket boosters.

A night-time test launch of the same prototype.



Above: Aptly coded '601 Black' (ie, *izdeliye* 60 No.1), the first prototype is shown here on its launch and control vehicle based on the BMD-1 paradroppable AFV at the Yakovlev OKB's flight test facility (note the Yak-42 in the background). The RPV appears to have an optically flat forward-looking camera port.



The second prototype *izdeliye* 60 ('02 Red'), shown here inside a hangar at the OKB's flight test facility, was the first to feature the intended parachute recovery system (its bay is open) and inflatable bumper. Judging by the hemispherical dielectric radome, this example was completed in ECM configuration.

accommodating the fuel tank, the wing folding/locking mechanism and the basic aircraft systems and equipment, and a rear section housing the engine with its extension shaft. The rear fuselage section carried the tail unit – a wide-chord ring-shaped stabiliser attached by four struts, with one-piece control surfaces (rudder and elevator) at 90° to each other forming two diameters of the ring. Additionally, cruciform fins of trapezoidal planform set at 45° to the horizontal plane were mounted immediately aft of the wings.

The RPV was powered by a P-020 air-cooled two-cylinder horizontally opposed engine delivering 20 hp at 7,300 rpm; this two-stroke engine with a displacement of 274 cc was developed by the design bureau of the Kuibyshev engine plant named after Mikhail V. Frunze. The plant is now known as the *Mo**tor**ostroi**te**l'* (Engine Manufacturer) Joint-Stock Co., while the design office is called SKBM (*Sa**mar**skoye kon**strook**torskoye byu**ro** mo**tor**ostro**yen**iya* – Samara Engine Design Bureau). The engine drove an AV-23 two-bladed fixed-pitch ducted pusher propeller of 600 mm (1 ft 11⅝ in) diameter via an extension shaft; the annular stabiliser doubled as the propeller duct, increasing the propeller thrust and control surface efficiency.

The *izdeliye* 60 was launched from a vehicle-mounted sloping ramp, using two solid-fuel rocket boosters for take-off. A parachute recovery system installed in a fairing atop the centre fuselage made for a safe landing; a smooth touchdown was ensured by an inflatable bumper made of rubberised nylon fabric under the centre fuselage.

As already mentioned, overall responsibility for the programme was assigned to the Koolon research institute headed by Anatoliy S. Novosyolov. The Moscow-based Gorizont (Horizon) OKB, then headed by V. V. Il'yichov, was tasked with designing the launch system. OKB-115 developed the UAV and performed integration of all systems. It should be noted that, despite its small size, *izdeliye* 60 was developed just like any other military aircraft; the approach to the design was the same, as all applicable design standards had to be met. Of course, it was not developed with record-breaking performance in mind; the main objective was to meet the requirements of the customer (that is, the VDV).

Basic specifications of the tactical unmanned aerial reconnaissance system based on the Pchela-1 (*izdeliye* 60)

Length overall	2.7 m (8 ft 10⅜ in)
Wing span	2.4 m (7 ft 10³¼ in)
Wing area, m² (sq ft)	1.4 (15.0)
Launch weight, kg (lb)	98 (216)
Speed, km/h (mph)	120-180 (74.5-112)
Flight altitude, m (ft)	100-1,000 (330-3,280)
Rate of climb, m/sec (ft/min)	3.5 (689)
Endurance, hours	2
Combat radius, km (miles)	30 (18.6)
Maximum number of RPVs airborne at any one time	1

The work proceeded fast. The first test 'launch' of a dummy version of the *izdeliye* 60 from a test rig took place at LII's test ground as early as 21st October 1982; eleven days later, on 3rd November, the dummy was 'fired' for the first time from the actual LCV. On 24th January 1983 the Yakovlev OKB took delivery of the first P-020 engine from the Kuibyshev engine design bureau; during the same afternoon it was fitted to the first flying prototype of *izdeliye* 60 (serialled '601 Black') in the presence of Minister of Aircraft Industry Ivan S. Silayev who was visiting the OKB to check up on progress. Meanwhile, the Koolon research institute was going full steam ahead with assembly and debugging of the radio control system and other avionics.

By then the Yakovlev OKB had built up a close-knit team of specialists which took all the problems associated with the RPV's development and operation in its stride. The design and production technology team included first and foremost V. I. Sergin, Ye. F. Shatalina, S. S. Sharin, Yu. N. Ivanov, Yu. N. Viryachev, B. N. Dedkov, N. V. Mel'nikova, A. L. Toobin, Yu. P. Salykov, V. N. Ganyushkin, A. A. Yakoobov *et al*. Test engineers Ye. P. Golubkov, A. I. Goortovoy, V. I. Palyonov, V. V. Tsaryov, V. I. Zasypkin, M. N. Veselov, V. N. Myasnikov, V. N. Pirogov, A. T. Volkov, S. A. Moorashov, B. B. Korochkin, S. D. Terent'yev and Ya. M. Galinskiy were also involved. A special UAV production department was set up at the OKB's experimental plant, MMZ No.115 'Strela'; it included a highly skilled manufacturing workforce headed by A. F. Vetrov, V. N. Boormistrov, I. S. Ovsyankin and A. G. Korolyov. At various times the group of UAV project engineers included V. F. Kulichenko, N. N. Dolzhenkov, V. A. Mit'kin, V. I. Baranov, A. I. Ovchinnikov, S. K. Koozin, Yu. V. Verkin, P. A. Rips, S. V. Dolinskiy, V. O. Zavarykin and V. K. Sharapov.

A special task force of high-class specialists was formed at MMZ No.115 for promptly resolving the issues arising during construction of the izdeliye 60 prototypes; it was headed by the plant's Director, S. D. Savin. Meanwhile, various components of the unmanned aerial system passed preliminary checks at a test ground near Moscow; for safety (and security) reasons, however, the testing of the system as a whole was to take place at a specially equipped and instrumented test range well away from residential areas and nosy parker neighbours.

On 22nd February 1983, a day before the Soviet Army Day celebrations, representatives of the principal OKBs and research institutions participating in the programme arrived in force at one of the test ranges operated by GNIKI VVS (the new name of GK NII VVS) together with the hardware to be tested. Considering that they arrived by air, and considering who the system was intended for, this could jokingly be called an 'airborne assault'. The commanders of the test ranges had long since allocated a stretch of wasteland with several auxiliary buildings in the middle of nowhere, about 40 km (25 miles) from the range's main facility, for the UAV test programme. While the tech staff was preparing the ground control station (GCS) and the aircraft for operation at the maintenance area, bulldozers pushed their way arduously through the deep snow to make a road to what would be the launch pad.

At the crack of dawn on 5th March 1983 the whole team was in position at the range. It was a bright and sunny morning, with dazzlingly white snow sparkling under endless deep blue skies as far as the eye could see, and the temperature was a crisp –15°C (+5°F), so everyone was in an oh-what-a-beautiful-morning-brr-it's-so-damn-cold state of mind. The men put on whatever clothes they had brought with them to keep warm, but the adjustment operations on the aircraft and inside the GCS could only be performed with bare hands, and eventually nature won. Still, the men held on, and at 13.07 Moscow time the RPV was finally installed on the launch rail. Imagine the consternation of the entire team when it turned out that the rocket boosters had been taken away to the main facility early in the morning for warming up to make sure they would fire properly – and were still there, 40 km away. An hour later, at 14.05, the boosters had been fitted and everything was set for launch – and then the autopilot's pitch control channel failed.

Thus, instead of a first flight the tests began with an incident investigation – not the most encouraging start. At an MAP conference dealing with the matter it was decided to change the launch technique, dispensing with the troublesome rocket boosters and using a catapult; eventually, however, the boosters were retained, albeit in modified form. The effort to redesign the launcher, modify the aircraft and perform bench tests of the new system lasted nearly three months.

On 17th June 1983 the efforts finally paid off: at 16.00 Moscow time the *izdeliye* 60 prototype made its successful maiden flight. After a five-minute flight the RPV was guided to a safe landing which involved the use of a recovery net similar to the crash barriers used on military airfields. There was a lot to recall that night at the festive dinner held in the open to celebrate the occasion – the long months of persistent work, the ups and downs of the

design and test process, the meetings (and occasional dressing-downs) at the ministerial level and so on.

The second launch that followed on 28th June was also successful, albeit accompanied by a hair-raising experience. After clearing the launcher rail the RPV did not proceed on its assigned course immediately; instead, it made a round of the launch pad, descending gradually to 100 m (330 ft). Everyone standing in the open ran for cover, trying to find a ditch or a hole in the ground in case the runaway UAV should come their way. Imagine how the crew of a Mi-8 helicopter waiting its turn to take off right beside the launch pad felt. The chopper was to fly chase and pinpoint the location of the RPV's emergency landing, should anything go wrong; now it found itself in the rather unlikely position of being 'chased', and possibly even 'attacked', by the test article! Luckily, 45 seconds later the RPV recovered and the rest of the mission went as planned, the prototype landing in the designated area 15 minutes after launch.

Gradually, as the creators of the system built up experience, they became more and more confident that the system had a future – even though the next test mission on 26th July again proved abortive. By the end of October 1983 the 'score' (the success/failure ratio) after 15 test launches was 10:5 in favour of the designers and the system's basic performance was more or less clear, making it possible to draw up a so-called preliminary conclusion recommending the RPV and the system as a whole for series production. At this point, however, the *izdeliye* 60 was retrofitted with a more sophisticated TV camera in a characteristic spherical Perspex blister at the customer's insistence, and a while later an active jammer became available for installation in the RPV. The resulting additional series of tests dragged on for a long time because the winter/spring season, which had set in by then, was a rotten time for testing RPVs in the field.

The final launch of an *izdeliye* 60 under the special trials programme held jointly by the designers and the customer took place on 28th May 1984. A month later the state commission endorsed the trials report. A total of 23 flying prototypes of the *izdeliye* 60 with different equipment fits and a further nine examples for ground tests were manufactured by MMZ No.115 between June 1982 and July 1983. The trials programme included a total of 25 test flights, 20 of these being accepted 'for the record'. The concluding part of the trials report went:

'1. The system basically conforms to the technical outlook (that is, operational requirement – Auth.). *The feasibility of such systems has been confirmed.*

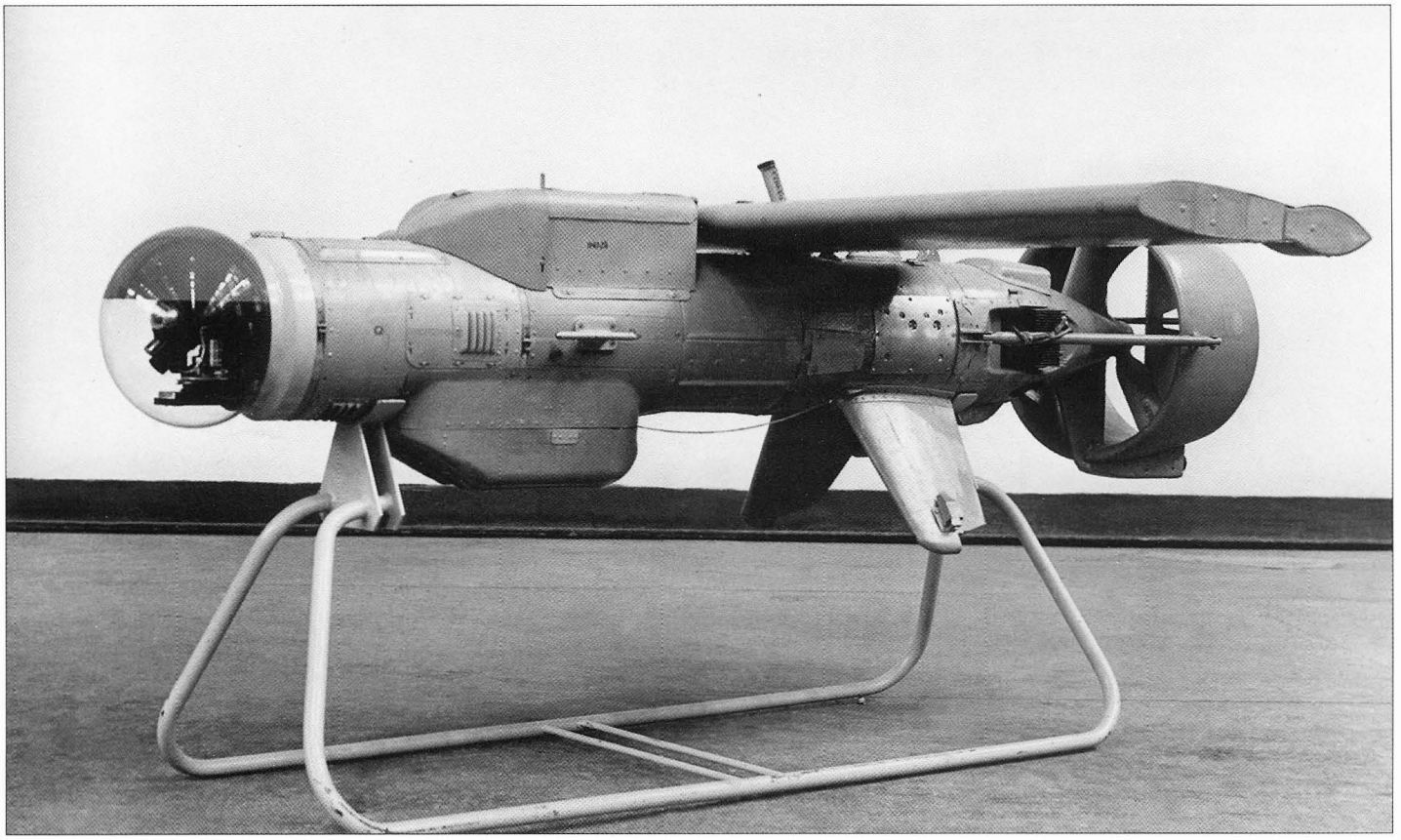
2. It is the recommendation of the undersigned that an initial production batch be manufactured for service trials.'

Pchela-1M (Pchela-1TM, *izdeliye* 60MS) tactical reconnaissance RPV

For another year or so virtually all of the Soviet Armed Forces' arms and services scrutinised Yakovlev's tactical unmanned aerial reconnaissance system, assessing its capabilities, before eventually giving it a thumbs-up. On 25th September 1985 the Council of Ministers issued a directive ordering an initial batch of 50 RPVs to be manufactured by aircraft factory No.475 in Smolensk. The production version was designated *izdeliye* 60MS (*modernizeerovannoye, sereeynoye* – upgraded, production) or Pchela-1M; the designation Pchela-1TM is also used, the T referring to the TV reconnaissance system in order to discern it from the ECM version described below.

The *izdeliye* 60MS differed from the prototypes in having a parachute recovery system which included an inflatable bumper; the parachute and the bumper were housed in prominent angular fairings above and below the centre fuselage. Another obvious recognition feature was that the upper pair of cruciform fins between the wings and the propeller duct was deleted.

Dozens of enterprises within the frameworks of several ministries were involved in the production of the RPV. As it did with all of its aircraft achieving series production, OKB-115 assigned a team of specialists (headed in this instance by project engineer S. K. Koozin) to monitor and support the pro-



No, this is not a skid landing gear, just a display stand. The production *izdeliye* 60MS (Pchela-1M) lacks the upper fins, the lower ones being retained for attachment to the launch sled. Note the 'fishbowl' nose housing a TV camera and the recovery system housings; the Pchela-1M would win no prizes at a beauty contest.

duction process, extending aid to the factory if necessary. Much attention was paid to the manufacturing standards of production RPVs and, even more importantly, to observing the delivery schedule. The OKB's new General Designer A. A. Levinskikh, who had succeeded Aleksandr S. Yakovlev after his retirement in 1984, exercised overall supervision of the programme.

A series of checkout and refinement tests involving six launches was held between May 1987 and 28th December 1987 to see if the production version of the system met the specs. In April 1988 the new tactical unmanned aerial reconnaissance system based on the Pchela-1M (*izdeliye* 60MS) RPV was delivered to first-line units of various arms and services for evaluation and operational tactics development.

Pchela-1PM unmanned ECM aircraft

A version of the Pchela-1M equipped with an active jammer was designated Pchela-1PM, the P denoting *posta**nov**shchik po**mekh*** – ECM aircraft. Outwardly it differed from the basic reconnaissance version in having the transparent 'fishbowl' nose housing the movable TV camera replaced with a hemispherical dielectric radome enclosing emitter antennas.

Sterkh tactical unmanned aerial reconnaissance system:

DPLA-61 Shmel'-1 (izdeliye 61) tactical reconnaissance RPV

From 9th June 1984 onwards the tactical unmanned aerial reconnaissance system based on the Pchela-1M (*izdeliye* 60MS) was officially assigned experimental status. The reason was that the ADP of a much-improved version of the system (regarded as the definitive version which was to enter full-scale production and service) passed its in-house project review at the Koolon research institute that very day. Designed to meet an SOR issued by the Ministry of Defence, the new system, which was subsequently named Sterkh (Japanese Crane), included the new Shmel'-1 (Bumblebee-1) RPV, alias *izdeliye* 61; some sources refer to it as the DPLA-61.

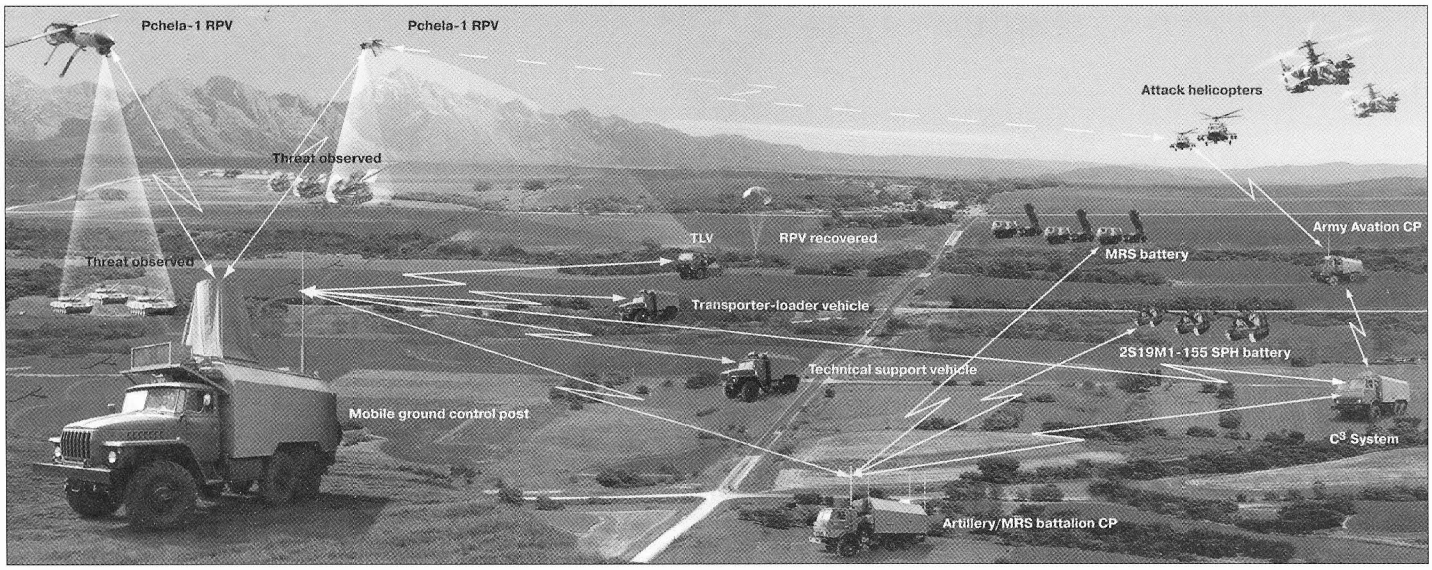
While the basic architecture of the system and the RPV's general arrangement were retained, the aircraft itself was a new design. In particular, the wings had a higher aspect ratio and specially profiled downward-canted wingtips instead of simple squared-off tips. The remaining ventral fins were deleted, as was the inflatable bumper; instead, the *izdeliye* 61 had a landing gear comprising two pairs of cantilever spring struts terminating in dished pads (although the first prototype lacked the landing gear). The recovery parachute housing ahead of the wings was relocated on top of the wing centre section and given an airfoil shape. The powerplant was also new – a 440-cc P-032 air-cooled flat-twin two-stroke engine developed by the same Kuibyshev Engine Design Bureau and delivering 35.5 hp at 6,600 rpm; it drove a new three-bladed propeller.

Ground testing of the system's components began on 1st December 1984. Nearly seventeen months later, on 26th April 1986, the first prototype *izdeliye* 61 bearing the

Basic specifications of the Sterkh system based on the Shmel'-1 (*izdeliye* 61)

Wing span	3.2 m (10 ft 5⅝ in)
Wing area, m² (sq ft)	1.8 (19.35)
Launch weight, kg (lb)	130 (286)
Speed, km/h (mph)	110-180 (68-112)
Flight altitude, m (ft)	100-2,500 (330-8,200)
Rate of climb, m/sec (ft/min)	4.0 (787)
Endurance, hours	2
Combat radius, km (miles)	60 (37.2)
Maximum number of RPVs airborne at any one time	2

An izdeliye 61 UAV on a very provisional launcher. Interestingly, this example has neither a landing gear nor a parachute recovery system, presumably being a full-scale mock-up. Note that the variable-sweep wings are set to forward sweep in this instance.



Above: This picture shows how the Stroy-P tactical unmanned aerial reconnaissance system is to interact with multiple launcher rocket systems, SP howitzers and attack helicopters. The ground part of the system is based on 6x6 lorries – Ural-4320 conventional 'crocodiles' and KamAZ-4310 cabovers.

serial '001 Black' performed its maiden flight at the same GNIKI VVS test range where the *izdeliye* 60 had been first launched in 1983. Continuing the 'tradition' established with the predecessor, the RPV again went haywire during the first launch – this time due to a software glitch in the control system computer.

After a debugging effort and a series of successful launches it was decided to hold full-scale manufacturer's tests and state acceptance trials of the Sterkh tactical unmanned aerial reconnaissance system based on the *izdeliye* 61 RPV fitted with TV reconnaissance equipment.

Shmel'-2 tactical reconnaissance RPV (project)

A version of the Shmel'-1 RPV featuring a retractable skid landing gear and a flexible parawing for horizontal landing was also under development. Designated Shmel'-2, it was to have a longer service life.

Stroy-P tactical unmanned aerial reconnaissance system:

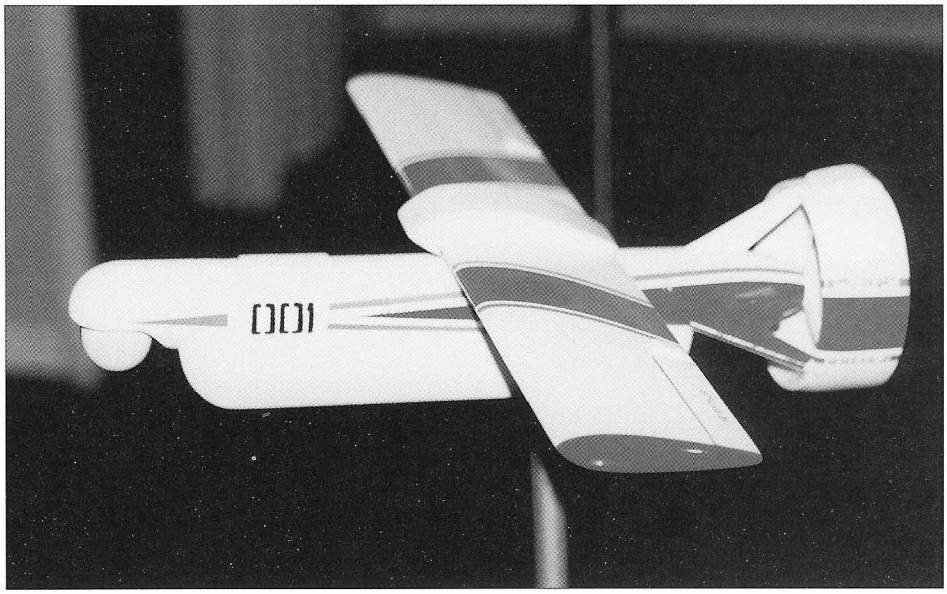
Pchela-1T (izdeliye 61T) tactical reconnaissance RPV

The moment of truth during the launch of the RPV came 15 seconds before the actual launch, when ground power was disconnected and the machine switched to autonomous mode. During this final countdown it was beyond human power to do anything – it was all up to the RPV's launch computer to 'take the right decision'. At the closing stage of the Sterkh system's flight tests/state acceptance trials (which proceeded in parallel) the 13 RPVs involved were 'given a chance to think' 68 times. On 52 occasions the flights were successful, being accepted 'for the record'.

The final stage of the state acceptance trials serving to verify the system's performance in mountainous areas was concluded on 28th September 1989. In the course of the trials the 13 *izdeliye* 61T RPVs, as the version of the Shmel'-1 equipped with a TV reconnaissance system was called (T = *televizionnoye oboroodovaniye* – TV equipment), logged a total of 50 flight hours between them. The early prototypes, such as '005 Black', had a 'goldfish bowl' nose patterned on that of the *izdeliye* 60 and simple (that is, not downward-canted) wingtip fairings. In due course the forward fuselage was redesigned; the new nose had a parabolic shape cut away (that is, flattened) from below to provide a mounting platform for a revolving hemispherical camera turret.

The test flights did not always go smoothly; six of the prototypes were lost in crashes, which equals an attrition rate of 46%. Despite this, the state commission's report said: *'...the system's performance renders it suitable for series production and service'*.

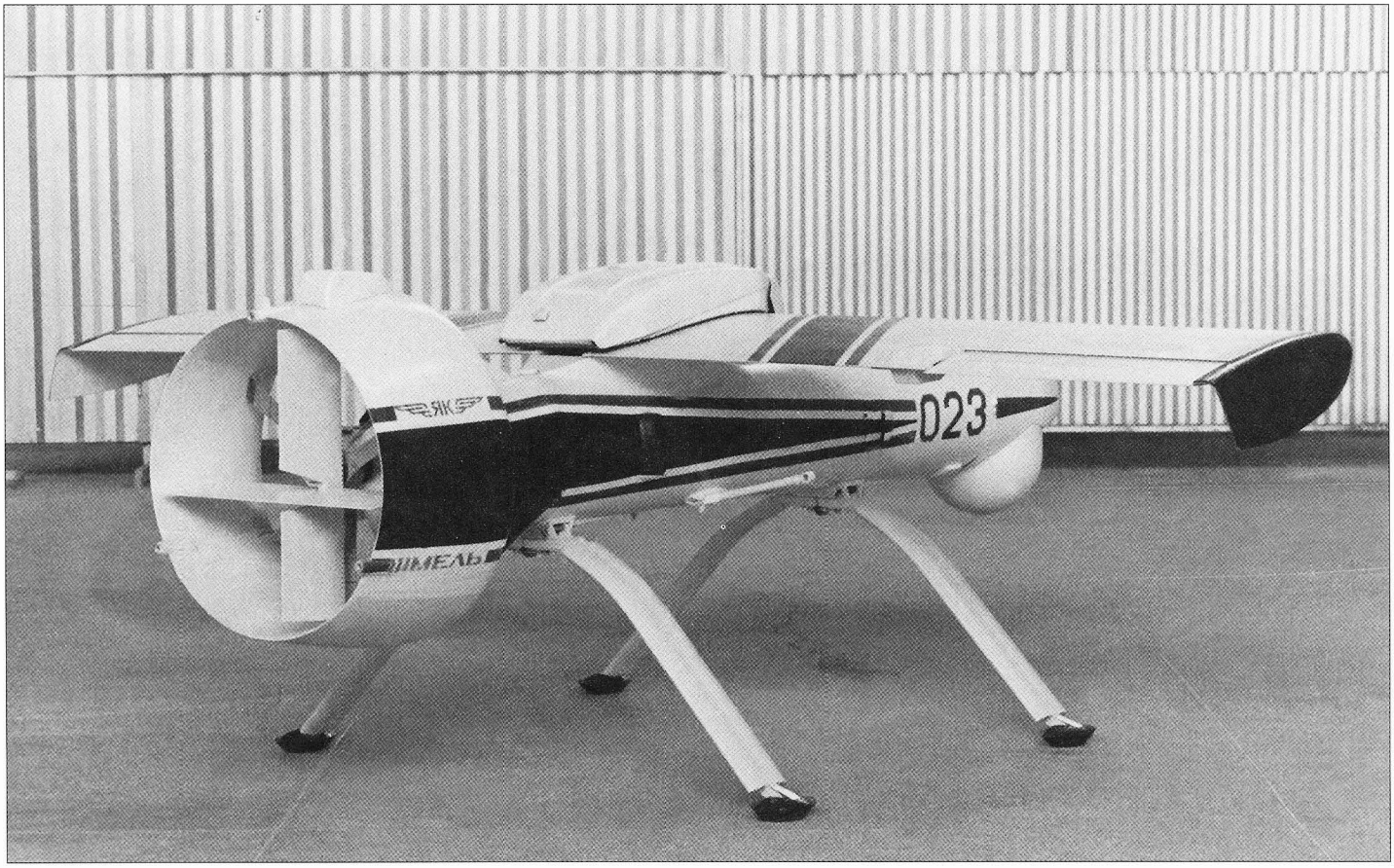
Some components of the new tactical unmanned aerial reconnaissance system were first shown publicly at the Moscow Aerospace '90 trade fair held at the VDNKh fairground (***Vystavka dostizheniy narodnovo khoziaystva*** – National Economy Achievements Exhibition) in December 1990. The system's international debut followed in July 1991 at the 39th Paris Air Show. The complete system was demonstrated for the first time at the MosAeroShow '92 at Zhukovskiy on 11th-16th August 1992 under the new name Stroy-P (Formation-P), while the UAV itself was now called, rather confusingly, Pchela-1T. The export version was still marketed as the Sterkh and Shmel' respectively.



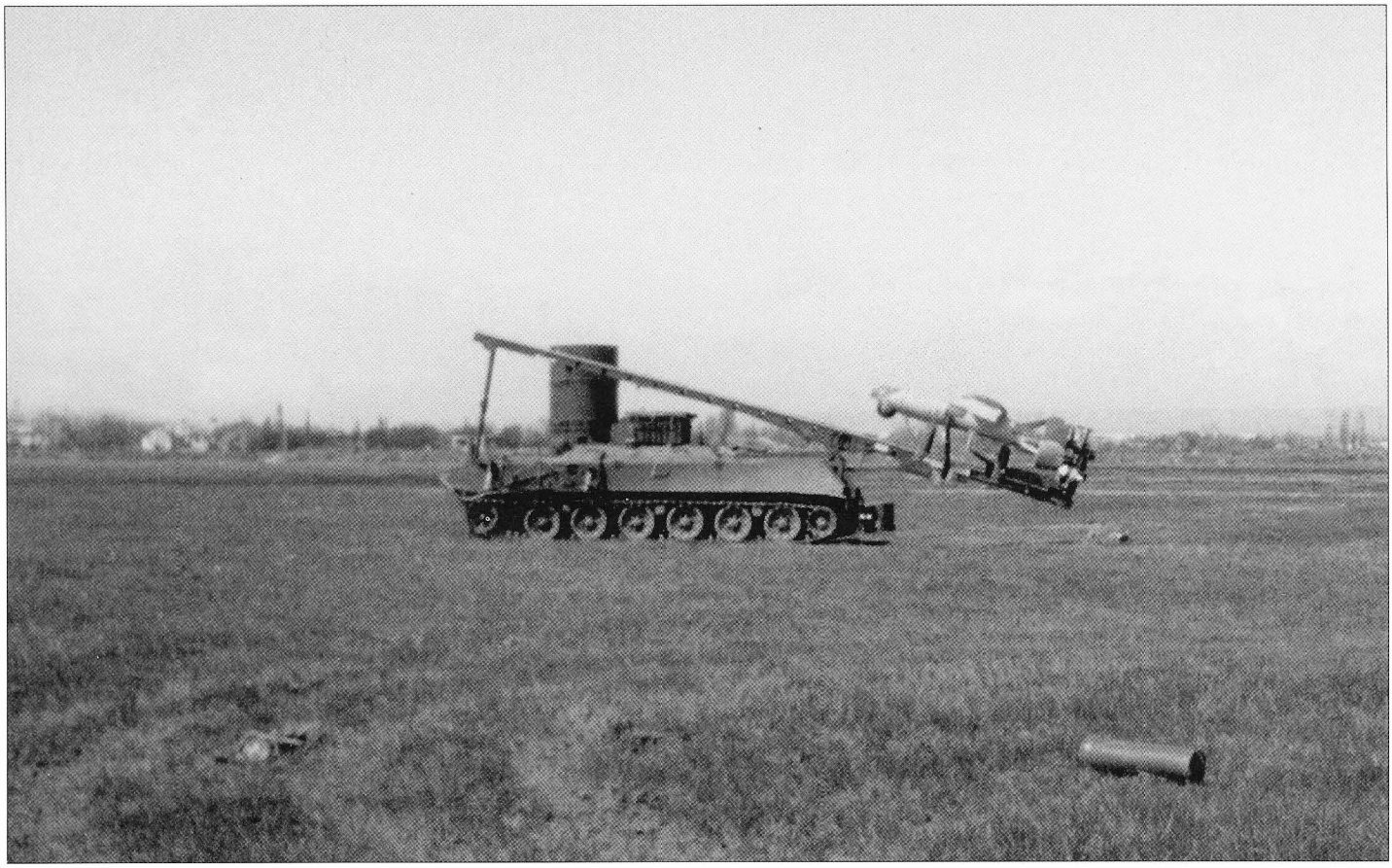
This scale model of the Shmel'-1 displayed at one of the Moscow airshows features a large ventral fairing which could be an inflatable bumper or an extra fuel tank.

Above: This Shmel'-1 UAV (alias Pchela-1T) serialled '023 Black' (the serial presumably matches the c/n) wears an unusual 'civil' demonstration colour scheme. This view illustrates the landing gear design, the parachute recovery system position and the undernose TV camera turret.

Another view of the same UAV. Note the two multi-pin ground power connectors ahead of the port wing and the strong sweep of the stabiliser attachment struts.



Above: Three-quarters rear view of '023 Black'. This example carries the Yakovlev OKB's winged logo and Shmel' titles on the stabiliser/propeller duct; the tail unit design is clearly visible. Note the raised bar amidships (a second bar is located to port); these bars connect the UAV to the launcher carriage.



A camouflaged Pchela-1T on its launch/control vehicle, all set for launch. The production LCV differs from the prototype version shown on page 67 in having a different launch rail and a large drum-shaped superstructure offset to starboard on the forward part of the hull.

Another view of the prototype LCV with a mock-up simulating one of the Yakovlev UAVs as regards weight, but not appearance.

A production LCV of the Stroy-P system a few moments after launching the UAV

Above: Pchela-1T '209 Red' on the LCV a few minutes before launch at a soggy practice range. Note the ground power supply arm attached to the UAV (it is disengaged 15 seconds before launch) and the lowered bars linking the centre fuselage with the launcher carriage.

The same UAV after landing, with the recovery parachute lying on the ground beside it. Note the open cover of the parachute housing and the position of the landing gear struts after landing.

Five production Stroy-P systems, each with a complement of ten Pchela-1T RPVs, had been completed and delivered to various arms and services by 1991; the first of these entered service in the Leningrad Defence District. On 16th June 1997 the Stroy-P tactical unmanned aerial reconnaissance system was finally formally included into the Russian Army inventory pursuant to Russian Government directive No.730.

The Pchela-1T/Shmel'-1 (*izdeliye* 61T) RPV has a designated service life of ten cycles. Its modular design makes sure that the principal airframe subassemblies (the fuselage sections, wings, empennage and landing gear) are interchangeable with the other versions of *izdeliye* 61, allowing the RPV to be easily assembled from standard components in the field.

The mission equipment of the Pchela-1T is a TV camera with a zoom lens mounted on a gyrostabilised platform under the nose; however, the modular airframe design makes it possible to quickly reconfigure the RPV for missions other than TV reconnaissance. For instance, fitting an active jammer turns it into an ECM aircraft capable of suppressing enemy UHF radio communications within a radius of 10-20 km (6.2-12.4 miles). A time-expired RPV can be converted into a target drone by installing equipment increasing its radar and heat signature (including transponders and tracers); this allows the Pchela-1 to emulate light aircraft flying at 120-180 km/h (75-112 mph) and 100-2,500 m (330-8,200 ft), such as might be used to insert or extract spies or saboteurs. (The Russian military sure learned their lesson after Mathias Rust's famous landing in Moscow's Red Square in a Cessna 150!) For night operations the TV camera can be replaced with infra-red line-scan or three-band scanning equipment.

The Stroy-P system comprises ten Pchela-1T RPVs, an integrated LCV based on what has been referred to in the Russian press as the 'BTR-D paradroppable amphibious tracked armoured personnel carrier' (although the shape of the hull and the running gear design correspond to those of the BMD-2 paradroppable AFV) and an evacuation/maintenance vehicle on a GAZ-66 chassis. All components of the system can be airlifted by Antonov An-12 and Il'yushin IL-76 transport aircraft or Mil' Mi-26 transport helicopters and paradropped on P-7 pallets with a multi-canopy parachute/retro-rocket system. After launch the RPV normally follows a pre-programmed route with up to 24 waypoints; if necessary the operator sitting in the LCV can take over and 'fly' the machine via radio control. The LCV's equipment makes it possible to control up to two RPVs at a time.

Starting in the late 1980s, the Stroy-P tactical unmanned aerial reconnaissance system has been used successfully in nine major military exercises. For instance, a special tactical exercise involving reconnaissance RPV launches was held in the North Caucasus Defence District in 1999; the flights of the RPVs were monitored by two Mikoyan MiG-29 fighters which tracked them with their fire control radars. This was the first exercise of the kind in the history of the North Caucasus DD. The squadron of Stroy-P systems was commanded by Lt. Col. A. Koshootin.

In the course of the exercise two RPVs penetrated deep into Blue Force territory. (In NATO exercises, the Blue Force is the 'good guys' and the Red Force is the 'bad guys'; in Soviet/Russian exercises, it's vice versa.) The first one turned back after travelling about 70 km (43.5 miles) from the place where it was launched. The mission of the second machine was more eventful; after covering more than 60 km (37.3 miles) in a straight line it made a 90° turn and flew another 40 km (25 miles) before making for home. Each aircraft had by then eight missions on its tail but had been performing flawlessly so far.

The first sortie that day ended in an 'oops': the recovery parachute broke away after deploying and the RPV spun in, slamming into the ground. That kept the fire and rescue crews busy for a while. Yet, incredible as it may seem, the mission equipment (including the all-important intelligence data recorder) was retrieved intact from the wreckage, so the mission had been a success after all. The second RPV landed normally. North Caucasus DD Aviation Commander Maj. Gen. Aleksey Bazarov, who was among the 'brass hats' attending the exercise, congratulated the squadron's personnel on the good results and on the fact that the unit had become fully operational. The latest exercise in which the Stroy-P system was involved took place near the Caspian Sea in the summer of 2002.

The system also saw actual combat – sadly enough, on its home ground, being used by the VDV and the Army alike during both Chechen Wars. Actually this was more like combat evaluation. The first combat sorties date back to May 1995, six months after the outbreak of the First Chechen War, when the Stroy-P aerial reconnaissance system was used by North Caucasian DD forces in support of Airborne Troops operations. Five Pchela-1T RPVs were in action on the Caucasian theatre of operations, flying ten sorties, including eight combat ones; total time was 7 hours 25 minutes.

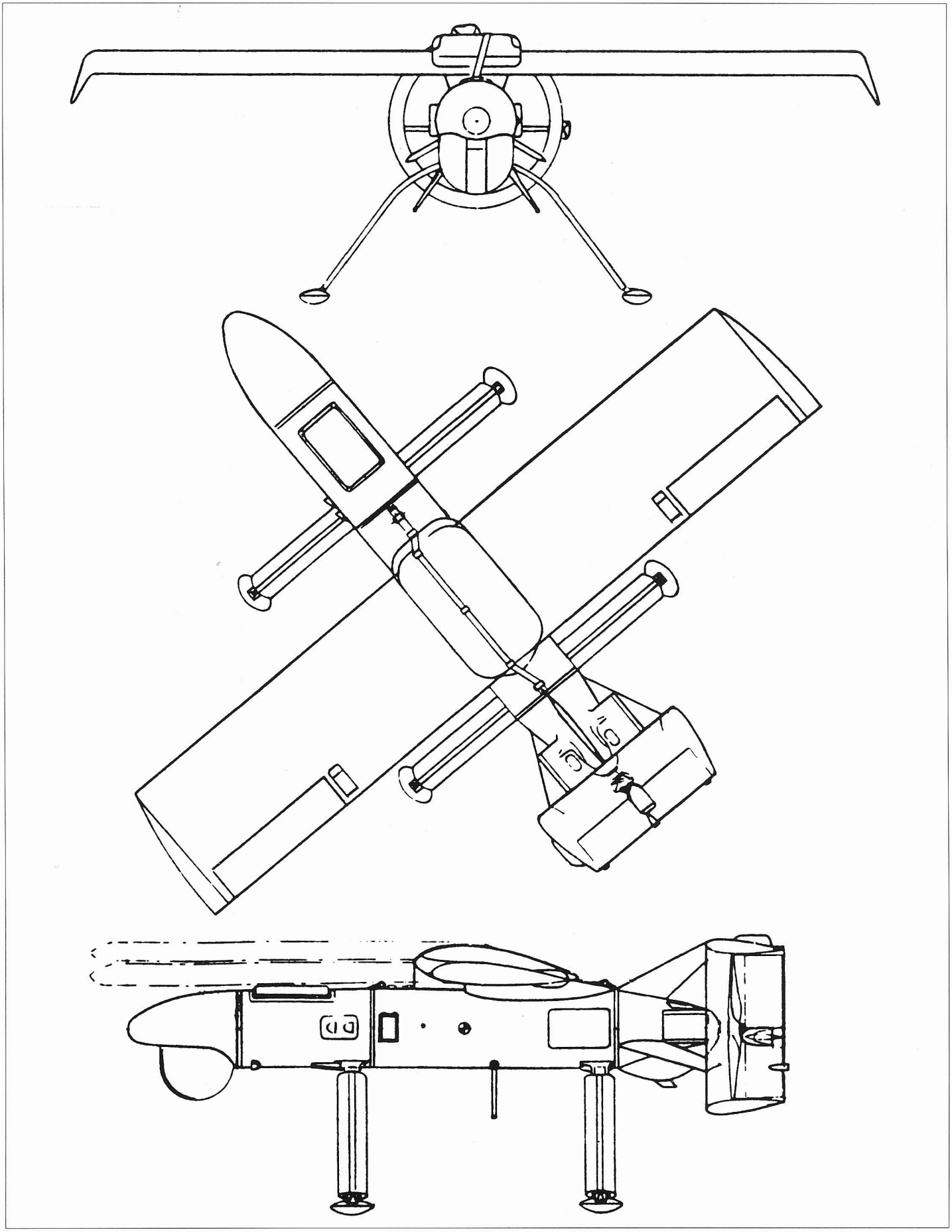
The machines flew their missions at 600-2,200 m (1,970-7,220 ft), operating up to 55 km (34 miles) from the LCV. In so doing, two of the 'bees' were shot down by the Chechen guerrillas who put up field AA guns and concentrated small arms fire along the RPVs' route. On the other hand, there were no casualties among the personnel operating the system. The 'bees' furnished unique information on enemy movements that would have been unobtainable by other means – at least not without high losses; this information was vital for Russian artillery units pounding guerrilla strongholds with rocket projectiles and for VDV commando groups on seek-and-destroy missions.

After a long pause caused by funding shortfalls, when the Russian Armed Forces were unable to re-equip for lack of money, production of the Stroy-P system resumed in the late 1990s. The ongoing hostilities in the North Caucasus were the primary reason for this; with the enemy cunningly hiding in residential areas and woodland, the Joint Task Force in the North Caucasus needed highly effective pilotless reconnaissance assets.

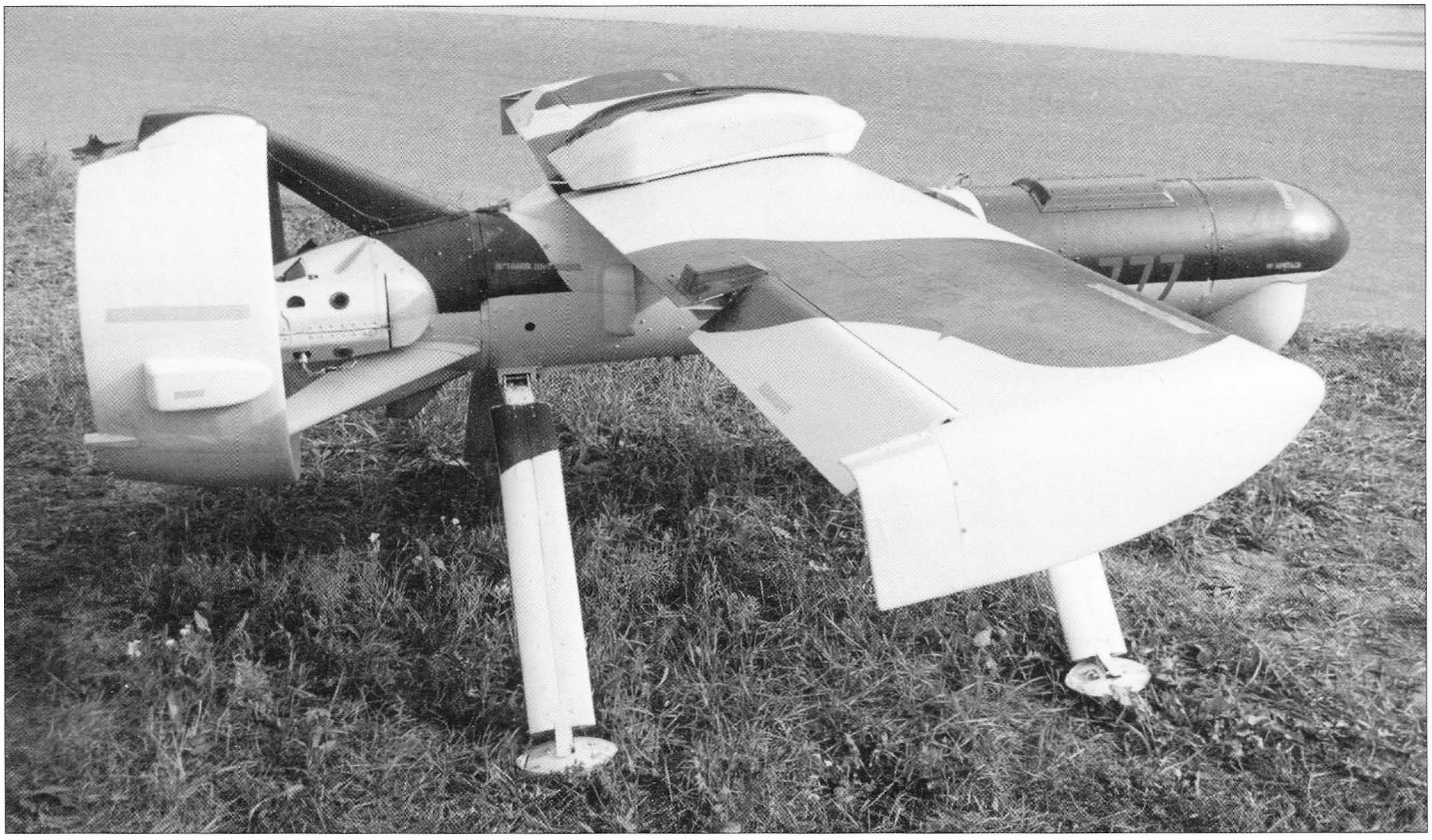
Trying to make the system more cost-effective, the Yakovlev OKB worked on increasing its service life; among other things, this was to be achieved by resorting to conventional landing, which imposed less stress and strain on the airframe than the parachute recovery technique. Back in the 1980s, when the Stroy-P system was created, no reliable means existed of giving a UAV automatic landing capability; in the meantime, however, aviation technology has advanced, and now such means can be developed in Russia fairly quickly and at an affordable price. Two versions of the upgraded system were envisaged; one would be mobile, like the existing model, while the other version would be permanently based at airfields, the RPVs using runways for landing. The latter version offered the advantage of lower operating costs; also, it would allow 'real-life' crew training to take place much more often than once a month, the way it is now.

Another thrust of the improvement effort was directed at giving the RPV round-the-clock capability. In particular, the upgraded Pchela was to feature a thermal imager linked to a laser rangefinder/marked target seeker; such an aircraft would be capable of not only reconnaissance but would act as a target designator for ground forces or manned strike aircraft (including those carrying laser-guided munitions). Also, a satellite navigation system receiver was to be fitted, allowing the target co-ordinates to be determined much more accurately.

Another possibility now under consideration is that of turning the Stroy-P system into a real-time artillery spotter. The Koolon research institute has developed an algorithm enabling the RPV to work in concert with the Smerch (Tornado) and Grad (Hail) multiple launcher rocket systems and the 152-mm 2S19M1 self-propelled howitzer. Tests of a reconnaissance/strike weapons system combining the Stroy-P system and a modified



A three-view of the Shmel'-1 (alias Pchela-1T) UAV; the folded position of the wings is shown by hatched lines. The stabiliser is shown in cutaway form to show the propeller and control surfaces.



The modular design of the Pchela-1T sometimes leads to peculiar results. This example ('777 Red') displayed at the MAKS-2003 airshow carried the c/n 5950611207408 on the wings and the c/n 5950611207340 on the stabiliser/propeller duct. Curiously, both ailerons are drooped.

Basic specifications of the Stroy-P tactical unmanned aerial reconnaissance system and the Pchela-1T (*izdeliye* 60)

Length overall	2.78m (8 ft 10⁹⁄₆₄ in)
Wing span	3.25 m (10 ft 7³¹⁄₃₂ in)
Height on ground	1.1 m (3 ft 7¹⁹⁄₆₄ in)
Combat radius (TV signal/control command reception range), km (miles)	60 (37.2)
Preparation time for a repeat sortie, hours	20
Flight altitude above sea level, m (ft)	100 to 2,500-3,000 (330 to 8,200-9,840)
Speed, km/h (mph)	120-180 (74.5-112)
Launch weight, kg (lb)	Up to 138 (304)
Rate of climb at sea level, m/sec (ft/min)	At least 5.0 (984)
Maximum launch altitude above sea level, m (ft):	2,500 (8,200)
Flight altitude above ground level, m (ft)	100-1,000 (330-3,280)
Turn rate, deg/sec (ft/min)	At least 3
TV camera field of view	3-30°
TV camera movement limits:	
in elevation	+5°/–65°
in azimuth	±170°
Target coordinate measurement error margin:	
in range, m (ft)	150 (490)
in azimuth	1°
Endurance, hours	2
Service life, cycles (each RPV)	At least 5
Operating temperatures	–30/+50°C (–22/+122°F)
Air humidity limit at +30°C (+86°F)	95%
Maximum wind speed, m/sec (kts):	
launch	10 (20)
landing	8 (16)
Minimum parachute deployment altitude, m (ft)	150 (490)
Maximum number of RPVs airborne at any one time	2
Control crew	2

Smerch MLRS gave impressive results; the MLRS's deployment/target engagement time was reduced by a factor of five to six, the expenditure of rockets was cut by 33%, and the total time from detection to destruction was no more than two or three minutes. The possibility of target designating for attack helicopters was also contemplated.

In 1997 a large group of Russian defence industry and MoD specialists was nominated for the Russian Government Prize for Science and Technology Development in recognition of their part in developing and putting into production the Stroy-P tactical unmanned aerial reconnaissance system based on the Pchela-1 RPV. Anatoliy S. Novosyolov, General Designer at the Koolon research institute, was the first in the list of nominees.

The operational experience with the Stroy-P gained at the Chechen TO is being used to further refine the system. The latest version utilises only cross-country wheeled vehicles – specifically, the GAZ-66 and the Ural-4320 6x6 army lorry; the elimination of tracked vehicles has cut operating costs and made the system more mobile.

The Pchela-1 in detail

Type: Reusable remotely piloted vehicle intended for tactical reconnaissance. The airframe is made entirely of GRP, which makes for a lightweight, easy to manufacture and sufficiently rigid structure.

Fuselage: Circular-section structure divided into four sections: the nose section housing the mission equipment, the avionics bay section, the centre fuselage and the rear fuselage. The centre fuselage houses the fuel tank and equipment bay; it also carries the wings and landing gear. The rear fuselage accommodates the engine and carries the empennage.

Wings: Cantilever shoulder-mounted monoplane wings of rectangular planform provided with ailerons and downward-angled tip fairings. They are one-piece structures mounted completely above the fuselage and rotating in line with the fuselage axis to save space for storage.

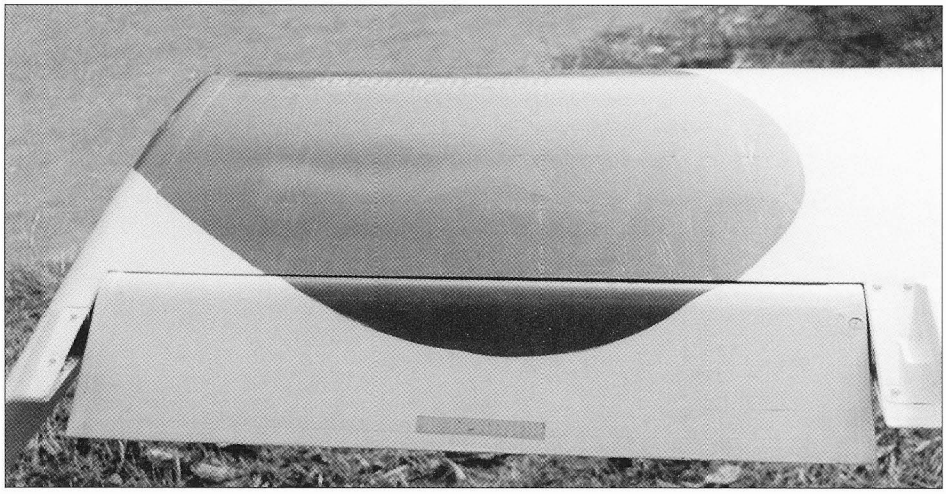
The wing folding/locking mechanism allows the wings to be locked into position at different sweep angles. The resulting change in longitudinal balancing compensates for the CG shift caused by different mission payloads, obviating the need for counterweights.

Tail unit: The empennage features a wide-chord ring-shaped stabiliser attached by three swept struts and acting as a propeller duct, with one-piece constant-chord control surfaces (rudder and elevator) at 90° to each other forming two diameters of the ring. The tail unit design serves to 'kill multiple birds with one stone', increasing the propeller thrust and rudder/elevator efficiency in all flight modes thanks to the prop wash, reducing the RPV 's acoustic signature to aid stealth and reducing the risk of personnel injury on the ground.

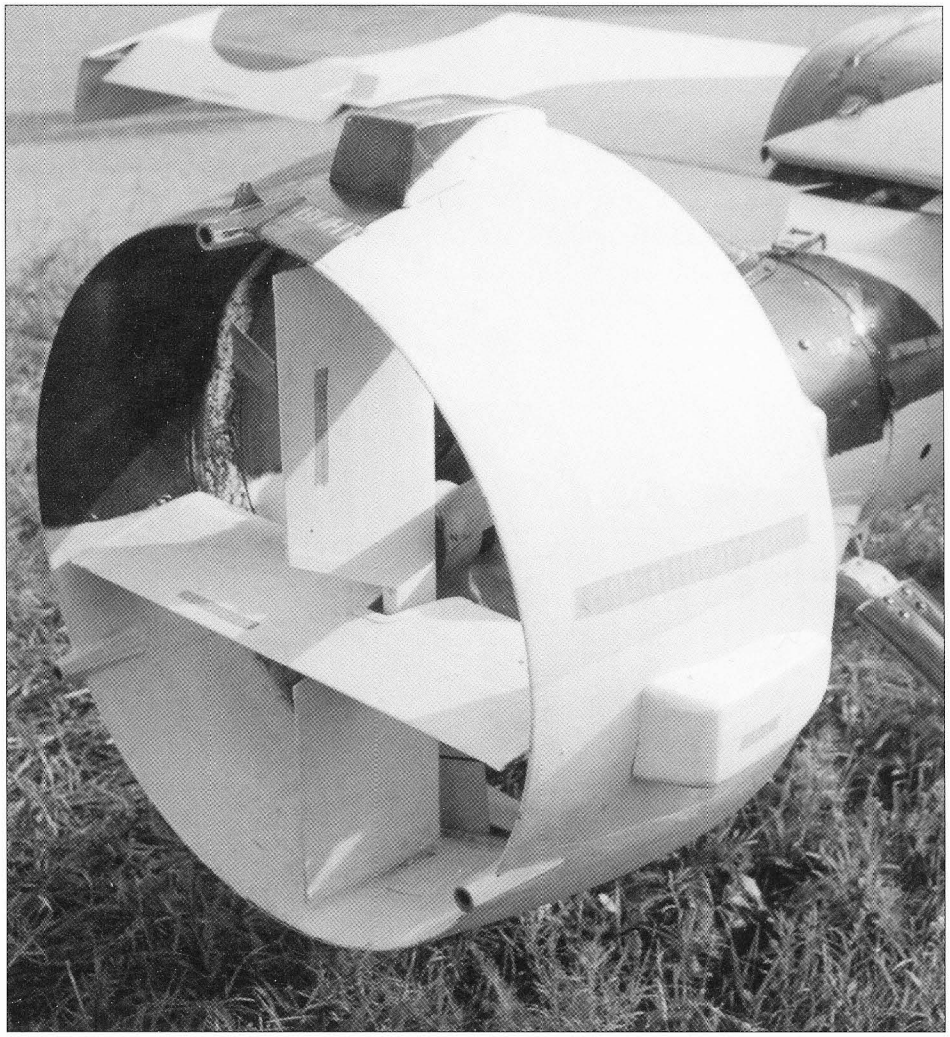
The Pchela-1 features a parachute recovery system stowed in a dorsal housing above the wing centre section; the aft-hinged cover is held in place by a strap released at the right moment. The landing gear consists of two pairs of cantilever struts with dished pads mounted fore and aft of the wings. Energy absorption is by means of steel strips which are torn on impact and are replaced before the next mission.

Powerplant: One 440-cc SKBM P-032 air-cooled flat-twin two-stroke engine delivering 35.5 hp at 6,600 rpm. Each cylinder has its own carburettor and fuel pump; a transistor ignition system is provided. Specific fuel consumption 0.38 kg/hp.hr (0.83 lb/hp.hr); compression ratio 7.0. Dry weight (less propeller) 13.1 kg (28.88 lb), length 505 mm (1 ft 7 1/16 in), width 454 mm (1 ft 5⅞ in), height 435 mm (1 ft 5⅛ in), engine life 50 hours. The P-032 runs on a 25:1 mixture of B-95/110 grade Avgas and mineral oil.

The engine drives a VVV-3-600 three-bladed fixed-pitch ducted pusher propeller of 600 mm (1 ft 11⅝ in) diameter via an extension shaft.



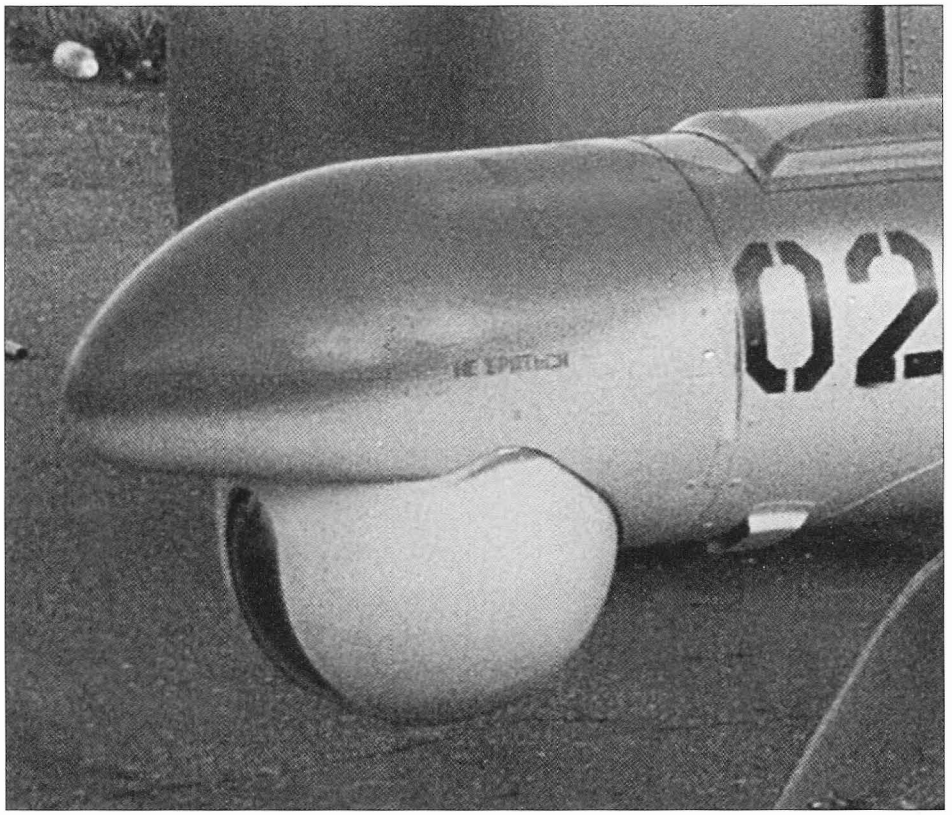
Above: The port wing and aileron of Pchela-1T '777 Red'; the fibreglass texture shows through the paint. Note the dorsal aileron actuator fairing. The c/n is stencilled along the leading edges of both wings.



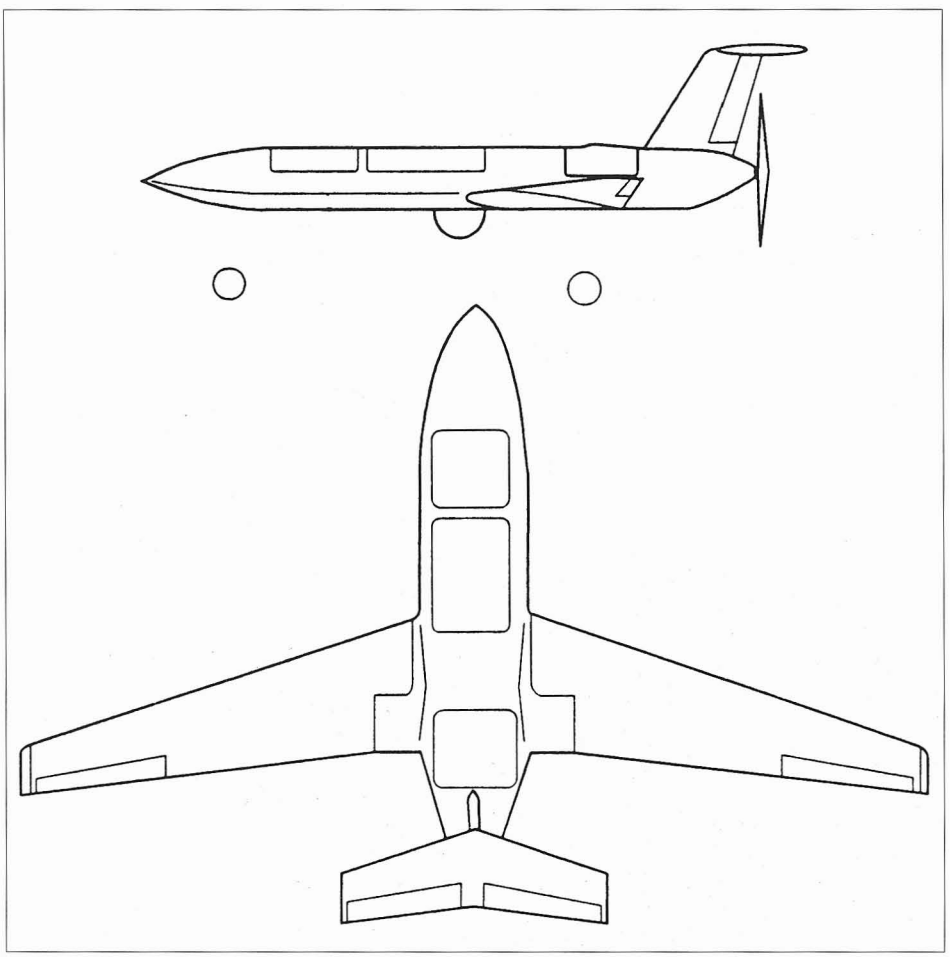
Close-up of the tail unit, showing the rudder/elevator actuator fairings and the cutouts in the control surfaces allowing them to intermesh. The c/n is on the starboard side of the annular stabiliser.

Control system: Autonomous control system enabling automatic flight along a pre-programmed route with up to 24 waypoints. The heading and altitude may be altered by the operator in the launch and control vehicle who enters the desired figures into the control computer.

Avionics and equipment:
Navigation and piloting equipment: An autopilot consisting of a computer into which the flight programme is loaded, a compass, a vertical gyro, a yaw/pitch/roll rate sensor and electric servos for the control surfaces and engine throttle.



Above: Close-up of the gyrostabilised TV system turret under the nose of Shmel'-1 '023 Black' (now in a more fitting green/blue camouflage scheme).



Two views of the projected Colibri reconnaissance UAV.

Mission equipment: A TV camera with a zoom lens or a thermal imager installed on a gyrostabilised platform under the nose. The TV camera's field of view varies from 3° to 30°, depending on the focal length; the operator in the LCV changes it at will, zooming in or out. The thermal imager's field of view width equals 75% of the flight altitude; the resolution is 3 mrad.

Operational details: The RPV is launched from a sloping guide rail mounted on a tracked vehicle, using two solid-fuel rocket boosters; landing is performed by means of a parachute recovery system; landing is possible at an unprepared (unpaved) but level surfaces.

The RPV is stored and transported in a GRP container which can be paradropped. The assembly/mission preparation time from arrival to launch is half that of the best Western counterparts.

The low aspect ratio wings provide acceptable aerodynamic characteristics while keeping the external dimensions to a minimum and enable transportation by any type of lorry. The chosen layout minimises the aircraft's dimensions and precludes stalling at low speeds. The modular GRP airframe facilitates series production, simplifies repairs and increases damage resistance. Even though the avionics turned out to be rather heavier than anticipated, the Pchela-1 meets the performance target.

Colibri unmanned aerial reconnaissance system (project)

In the early 1990s the Yakovlev OKB teamed up with one of the research institutes in Zelenograd (a town north of Moscow which is the Russian answer to Silicone Valley) to form the NPO AVICS research and production association. This consortium is responsible for a joint project of a successor to the Stroy-P tactical unmanned aerial reconnaissance system. Designated Colibri, it is based on an advanced UAV embodying stealth technology; the aircraft is slightly larger than the Pchela-1T and is to have an endurance of about 12 hours.

NPO AVICS paid much attention to improving the system's operating economics, including intelligence gathering costs. As distinct from the Pchela-1T, which was designed for use at the regimental level, the Colibri was intended for larger Army units (divisions or armies). The envisaged long range was to allow the UAV to be based up to 130 km (80 miles) from the FLOT, reducing its vulnerability to enemy action.

Intelligence gathered by the UAV (which was to have day/night, all-weather capability) was to be downloaded via data link to mobile user terminals situated at the forward line of

the troops the UAV was flying its mission for. Alternatively, it could be relayed to combat aircraft or helicopters to give their crews an indication of the situation near the target in advance, or to combat vehicles on the ground.

The use of standard laser designators made it possible to use a single UAV type for guiding laser-guided munitions of all types (cannon shells, missiles and 'smart' bombs). The result was expected to change the philosophy of ground combat completely; friendly forces would have constant information on the enemy's position, which would enable 'stand-off' engagement by means of precision-guided munitions. For instance, the Msta SP howitzer now in Russian Army service can fire guided shells at targets up to 20 km (12.4 miles) away; advanced 152-mm artillery systems should have twice the 'kill' range. Thus, the use of UAVs (among other things, in anti-terrorist operations) will allow Russian Army units to effectively locate and destroy targets over huge areas without changing their own position.

The Colibri is a low-wing aircraft with straight wings, a T-tail and a retractable tricycle undercarriage powered by a 75-hp engine driving a pusher propeller; it is to carry a mission load of 70 kg (154 lb). The maximum operating radius is 180 km (112 miles), increasing to 700 km (434 miles) if a second UAV acting as a communications relay platform is used.

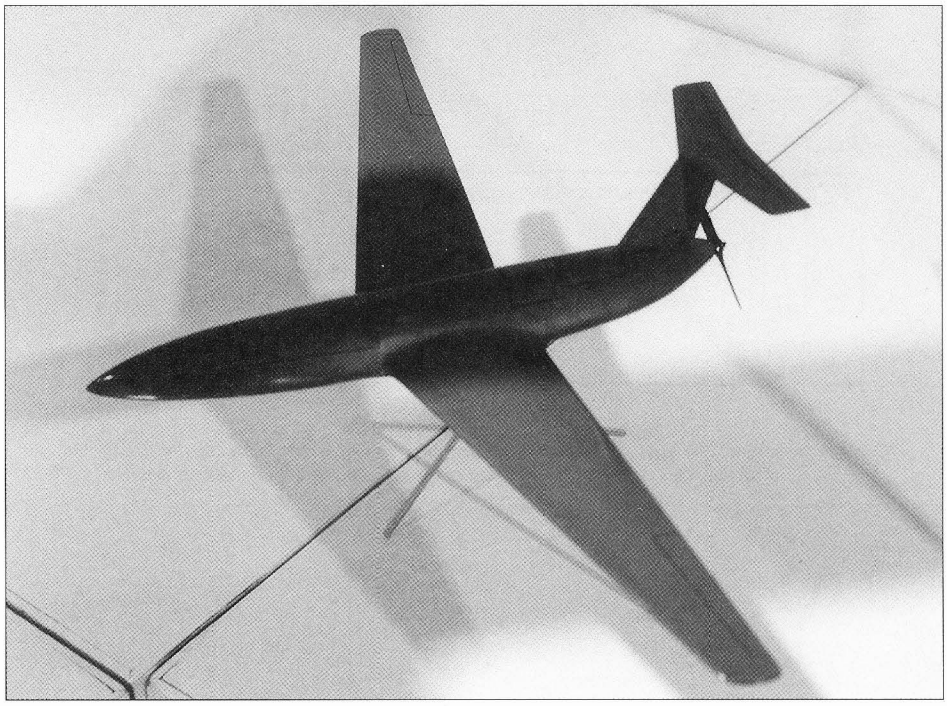
A model of the Colibri was displayed at the MAKS-93 airshow from 31st August to 5th September 1993.

Basic specifications of the Colibri unmanned aerial reconnaissance system

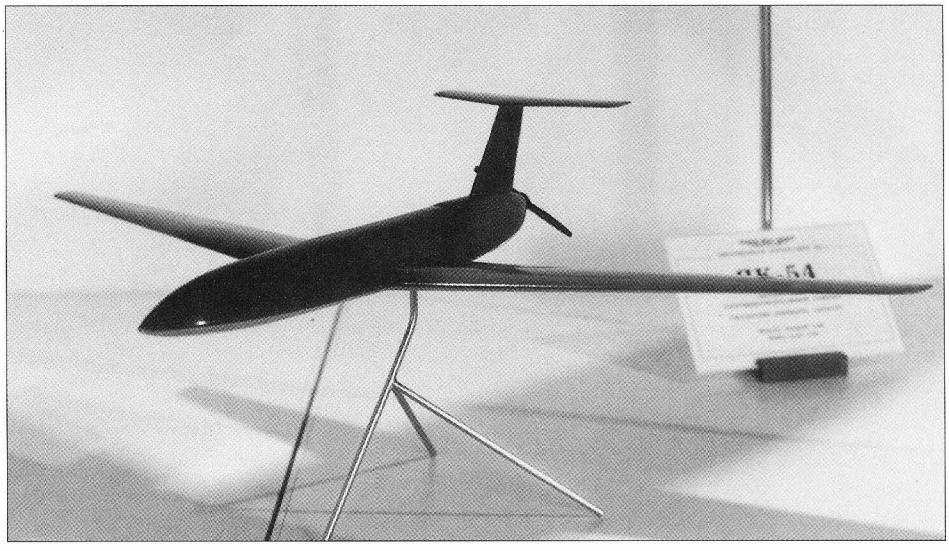
Length overall	4.25 m (13 ft 11¾ in)
Wing span	5.9 m (19 ft 4⅝ in)
Stabiliser span	1.7 m (5 ft 6⁵⁹⁄₆₄ in)
Launch weight, kg (lb)	280 (620)
Fuel load, kg (lb)	72 (158)
Payload, kg (lb)	70 (154)
Flight altitude above sea level, m (ft)	50-3,500 (164-9,840)
Speed, km/h (mph)	250 (74.5-112)

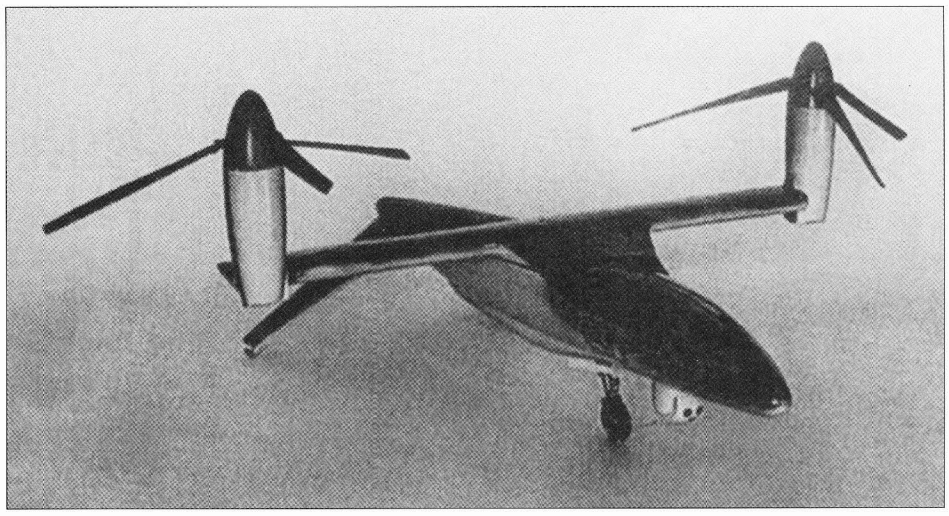
Yak-133BR unmanned combat/aerial reconnaissance system (project)

Another area of UAV design which is receiving much attention lately is UCAVs, and the Yakovlev OKB has pursued this subject at its own initiative. There have been press reports of Yakovlev UCAVs, including the Yak-133BR derived from the Yak-130 twin-turbofan advanced trainer. Actually the two have little in common, as the Yak-133 is a tailless delta. At an all-up weight of some 6,000 kg (13,230 lb), it compares closely to the Boeing X-45 and Northrop Grumman X-47 UCAVs.

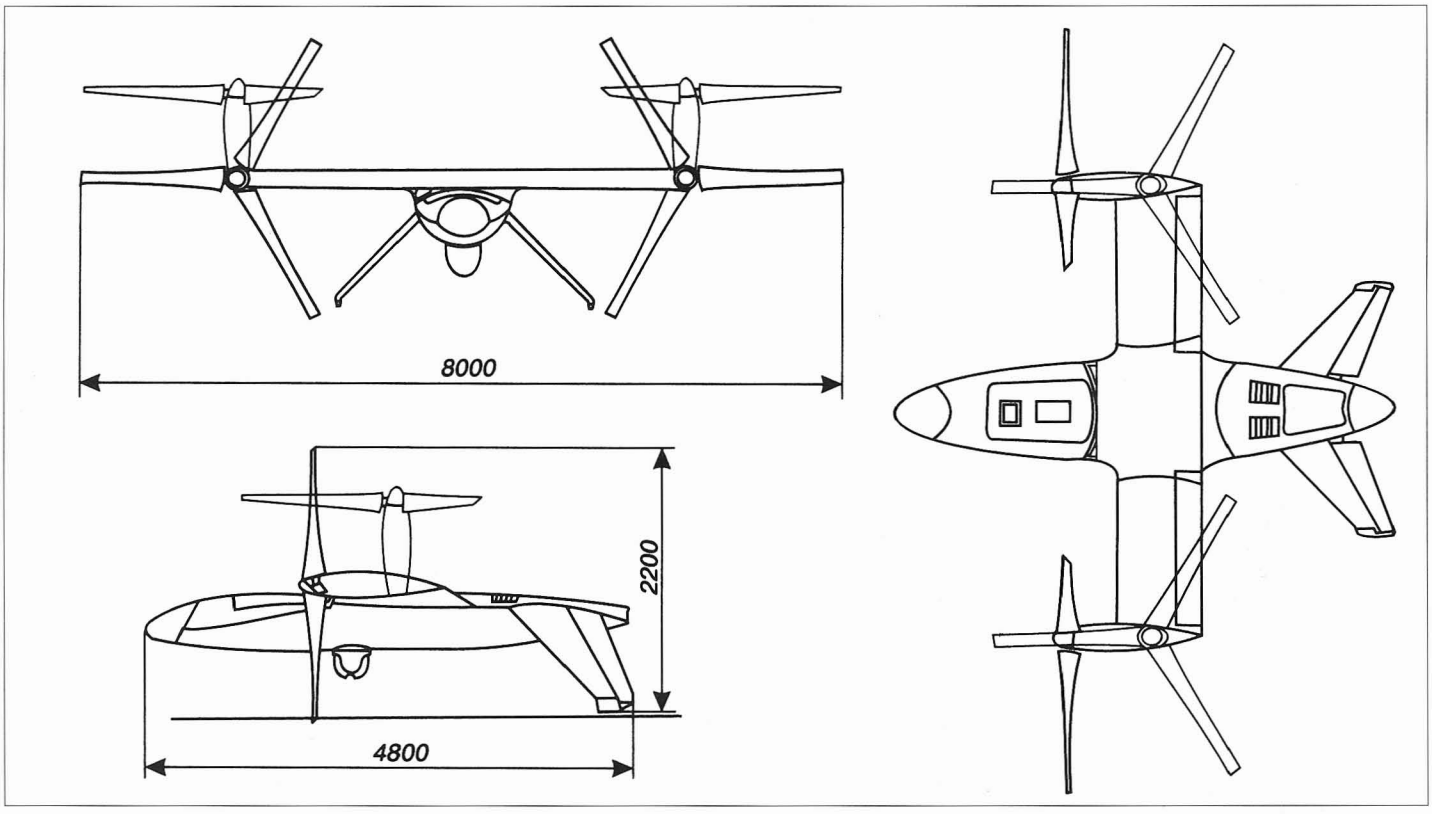


Above and below: This overall black model of the Colibri was displayed at the MAKS-93 airshow; curiously, it does not feature a reconnaissance system turret.





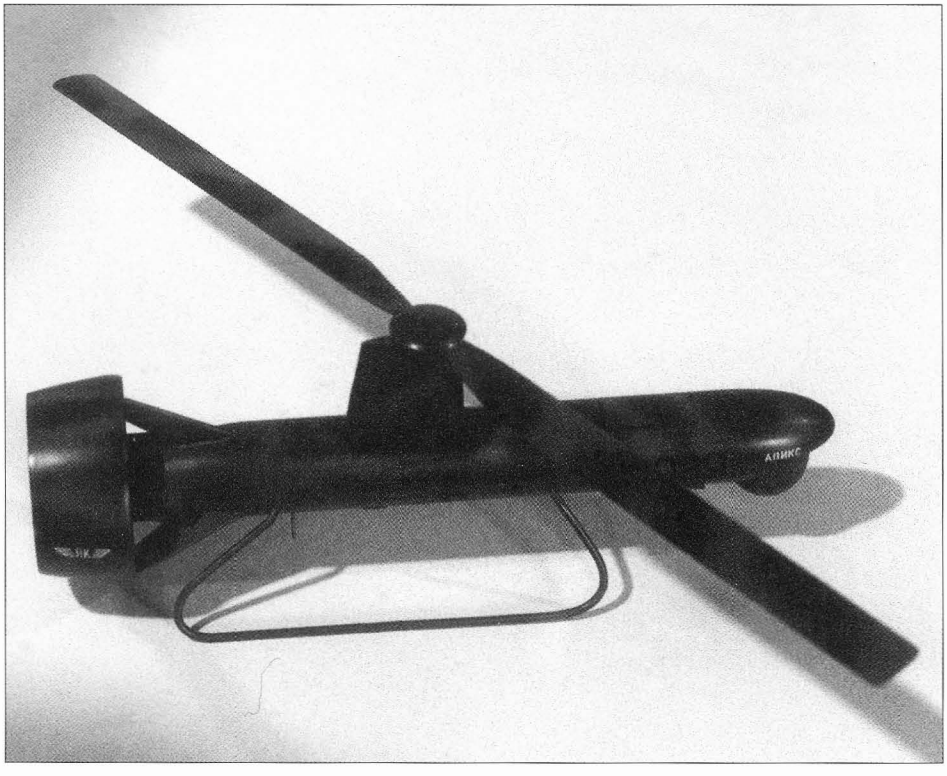
A model of the Albatross VTUAV with the final drive fairings/rotors tilted up. Note how the machine sits on its monowheel and inverted-Vee tail tips.



A three-view of the Albatross vertical take-off and landing UAV. The aircraft is 4.8 m (15 ft 8⁶³⁄₆₄ in) long and 2.2 m (7 ft 2³⁹⁄₆₄ in) high in cruise configuration; the 'wing span' with rotors turning is 8.0 m (26 ft 2³¹⁄₃₂ in).

PD work performed by the Yakovlev OKB shows that Russian unmanned reconnaissance and strike systems could be developed in time to keep up with the Joneses (that is, the NATO) and at an acceptable price. Yet, so far the Russian MoD has not clear-cut operational requirements for such vehicles, which hampers large-scale research in this field.

Now, however, the situation is slowly changing as the decision makers realise that the future of military aviation lies with unmanned aerial systems of various classes, including special mission UAVs. Russia's late start in the race could jeopardise both its defensive capability and the export potential of Russian aircraft.



A model of the Zhavoronok-1 autogyro UAV; its Shmel'-1 lineage is obvious.

Albatross VTUAV (project)

Starting with the MAKS-95, the Yakovlev OKB has been displaying models of its advanced compact UAV projects. These include a very intriguing project of a vertical take-off and landing UAV (VTUAV) designated Albatross. The 450-kg (990-lb) vehicle is a convertiplane featuring tilt-rotors at the tips of its unswept low aspect ratio wings. The machine has a blended wing/body design with an oval-section fuselage, an inverted-V tail unit and a monowheel undercarriage (the vertical tails double as supports on the ground). A single turboshaft engine is buried in the fuselage, breathing through two air intakes in the wing roots; the jetpipe is located ventrally and is screened by the vertical tails in side view to reduce the heat signature.

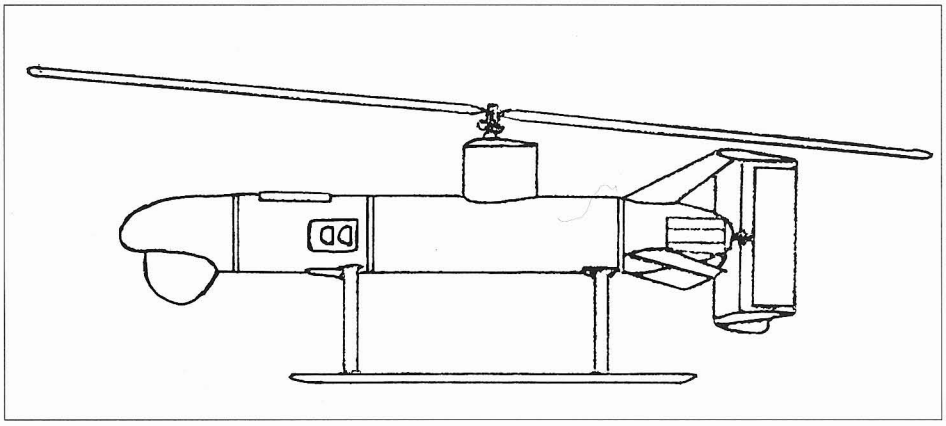
A hemispherical gyrostabilised turret with reconnaissance system sensors is located ahead of the monowheel. The mission equipment is to enable round-the-clock, all-weather operations.

Zhavoronok RPV autogyro (project)

Another product of the NPO AVICS consortium is an interesting UAV project called ***Zha****voronok* (Skylark). This is nothing other than an autogyro based on the airframe and

powerplant of the Shmel'-1 UAV. The wings and parachute recovery system have given way to a two-blade rotor driven by the slipstream; a skid landing gear replaces the four cantilever struts. The Zhavoronok is to be powered by either the P-032 engine or a Voronezh Engine Design Bureau (VOKBM – *Vo**ron**ezhskoye **op**ytno-kon**strook**torskoye byu**ro** mo**tor**ostro-**yen**iya*) M18-02 air-cooled flat-twin two-stroke engine delivering 55 hp at 2,200 rpm. The mission equipment placement is unchanged.

Two project versions differing in engine type, rotor diameter, landing gear design and payload are known. A model of one version was displayed at the MAKS-93 airshow on 31st August/5th September 1993.

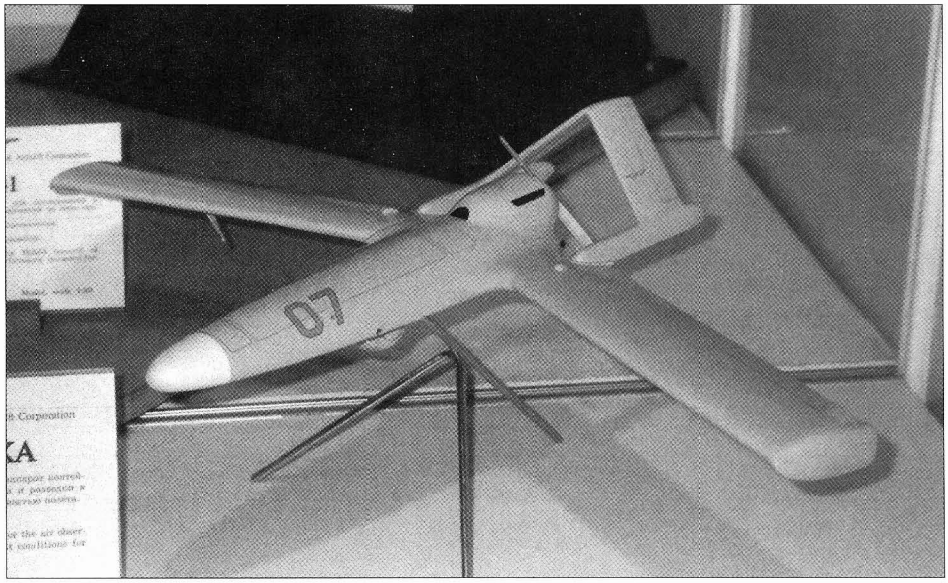


Above: A drawing of the projected Zhavoronok pilotless autogyro. Note that the landing gear design is different from the model on the opposite page. The stabiliser is shown in cutaway form.

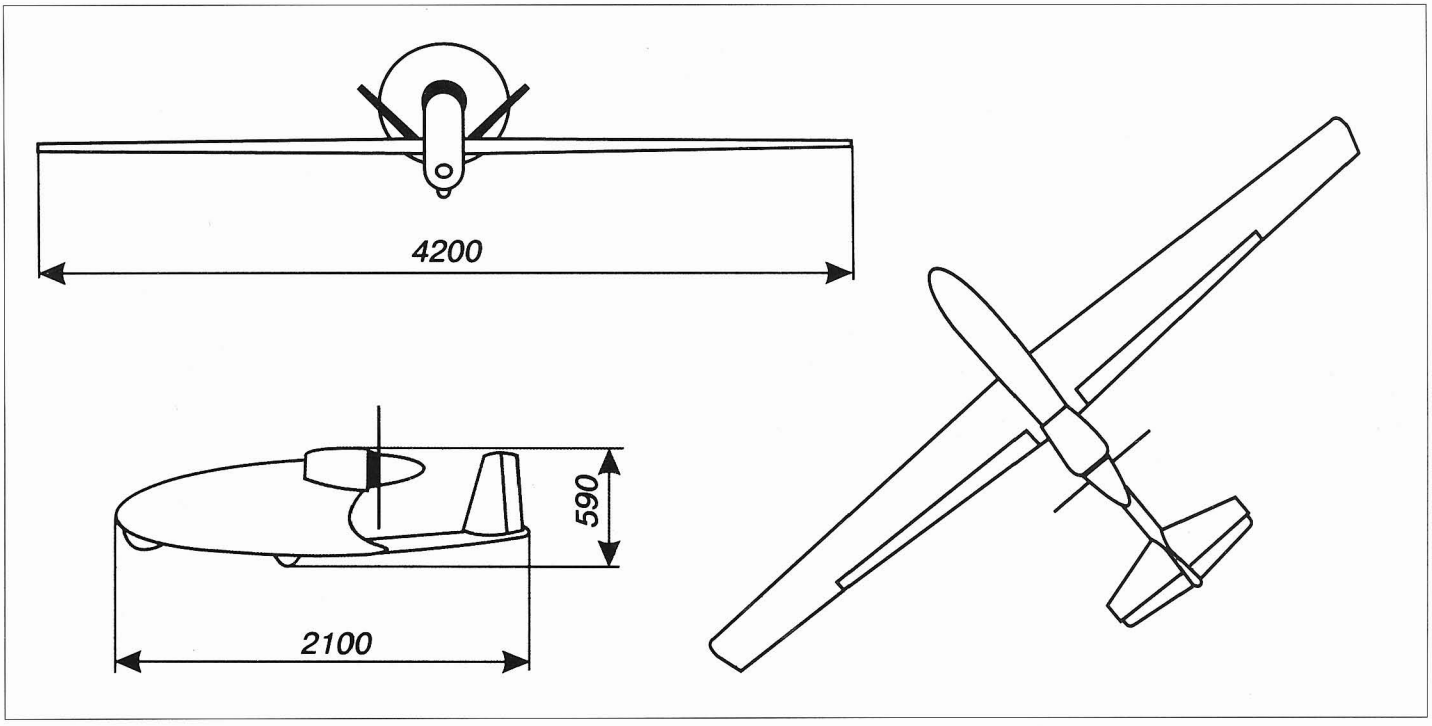
Malinovka mini-RPV (project)

Another Yakovlev mini-RPV optimised for lengthy reconnaissance or surveillance missions is called *Ma**lin**ovka* (Robin, the bird). The aircraft has highly unusual looks, featuring an integral (blended wing/body) layout with a flattened fuselage and wings with 23° negative sweep located well aft; the wings have downward-angled tips and fold forward for storage. Two tailbooms attached to the wing roots carry an inverted-V tail unit. A piston engine located atop the rear fuselage in a bulged cowling drives a two-blade pusher propeller. A hemispherical gyrostabilised turret with reconnaissance system sensors is located ventrally amidships. Like the Albatross, the Malinovka clearly embodies stealth technology.

The operational concept is rather unusual as well; the aircraft comes in a transport container which doubles as a launch tube! The Malinovka is extracted from the tube by a



Above: A model of the stealthy, tube-launched, forward-swept-wing Malinovka UAV. The reconnaissance system turret is just visible under the fuselage.

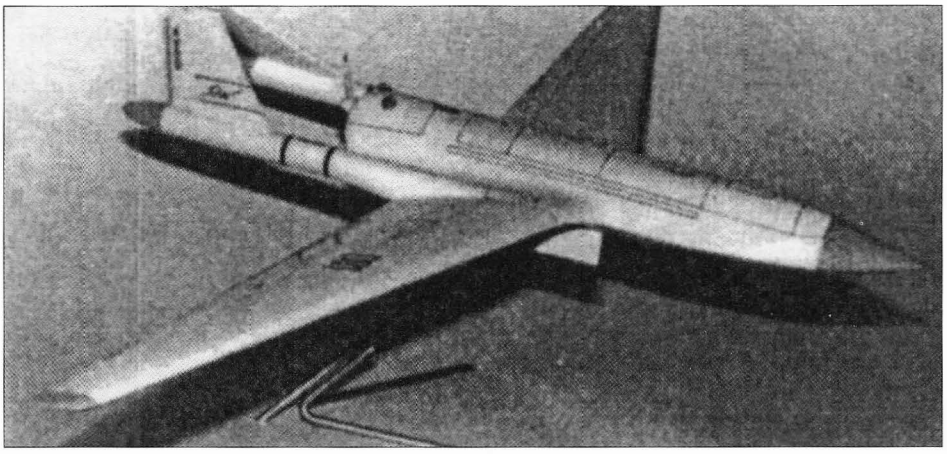


A three-view drawing of the Expert compact UAV. It is 2.1 m (6 ft 10$^{11}/_{16}$ in) long and 0.59 m (1 ft 11$^{15}/_{64}$ in) high, with a wing span of 4.2 m (13 ft 9$^{23}/_{64}$ in).

squib attached to the aircraft by a long line, the wings deploying as the aircraft clears the opening; the squib then falls away as the aircraft climbs under its own power. A parachute recovery system is used for landing.

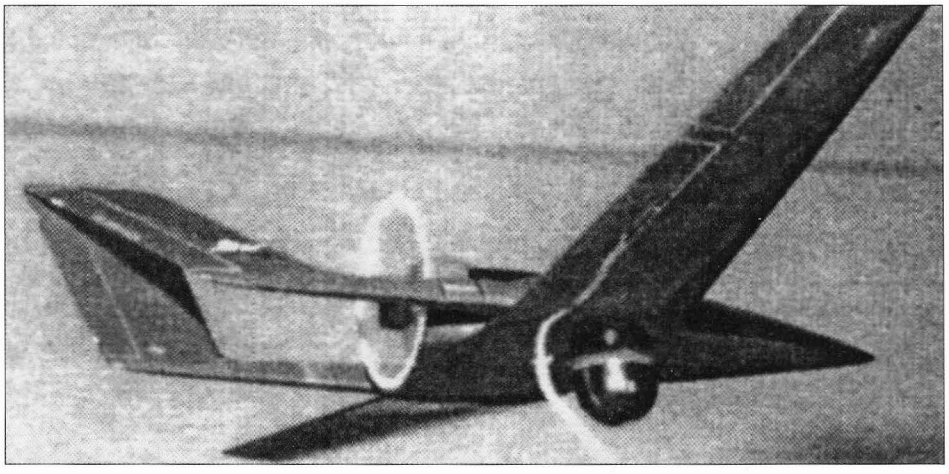
A model of the Malinovka was first displayed publicly at the MAKS-95 airshow.

Other Yakovlev UAV projects using this twin-boom/inverted-V tail pusher configuration include the swept-wing ***Dyatel*** (Woodpecker), the similar but shorter Klyost (Crossbill) and the much larger, straight-wing, high-flying Oryol (Eagle) strategic reconnaissance UAV with a retractable tricycle undercarriage. Few details have been released on these projects so far. (Hmm. Bees, then birds... only the butterflies are missing to complete the proverbial triad.)



Above: A model of the Dyatel UAV. The machine has an inverted-V tail carried on twin booms and a pusher propeller; the sharp-chined fuselage blended with the wings appears to have an internal payload bay.

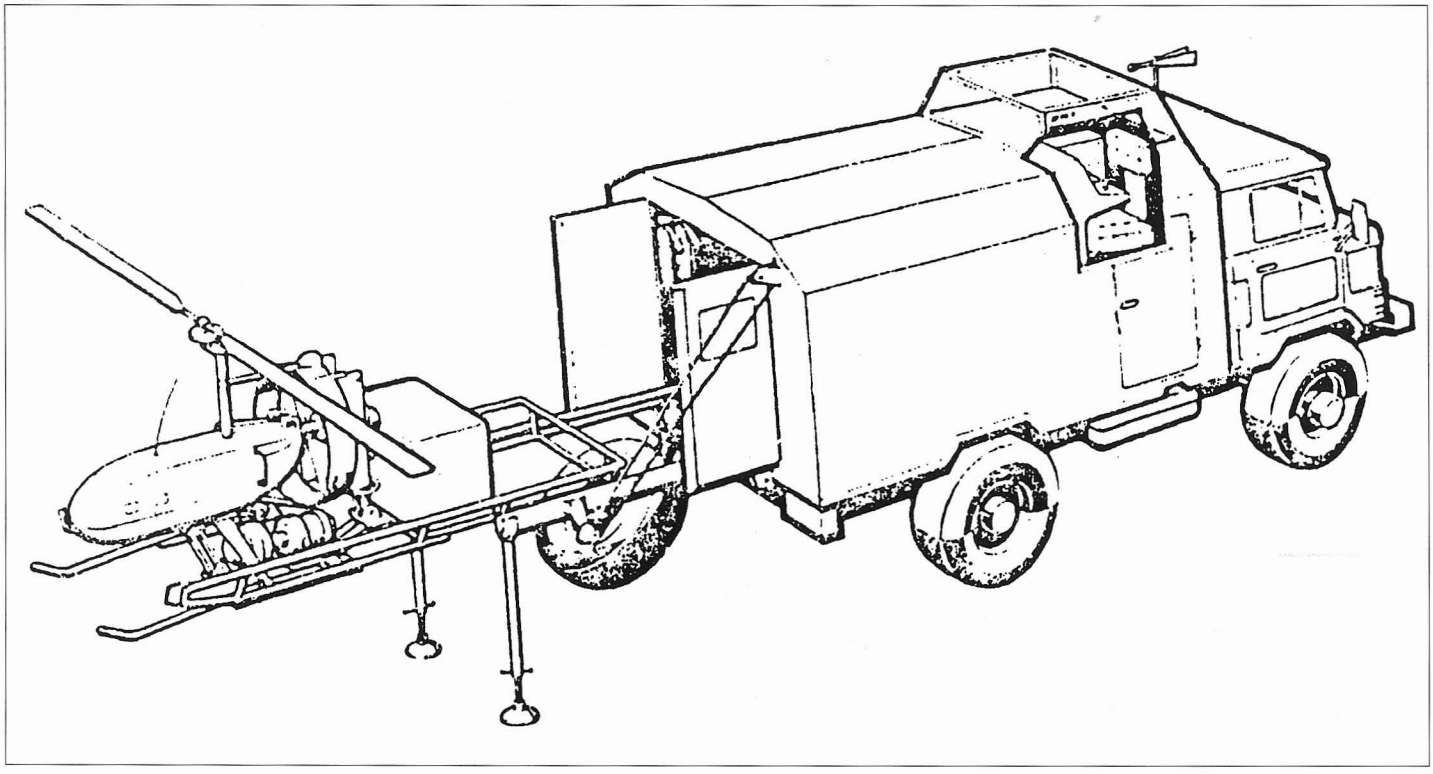
Below: The broadly similar but smaller Klyost UAV, showing the ventral sensor turret.



Expert mini-RPV (project)

Yet another unmanned aerial system the Yakovlev OKB has in the making – the Bars (Snow Leopard) – is to feature an RPV with an all-up weight up to 60 kg (132 lb). The system makes use of the latest technologies, including SATNAV systems, electronic maps and electronic components borrowed from spacecraft production. The operator's workstation is based on a laptop computer.

One of the UAVs that could be part of the Bars system is the Expert mini-RPV with an AUW of 40 kg (88 lb) intended for civilian applications. It utilises a pod-and-boom layout with a butterfly tail at the end of a slender tailboom, a pusher propeller and a fixed monowheel undercarriage.



Above: This drawing depicts an autogyro UAV project developed by the Yakovlev OKB; it is very different from the Zhavoronok and is obviously a separate design. The transporter/control vehicle with a slide-out tray for the UAV is based on the GAZ-66 army lorry.

Chapter 4

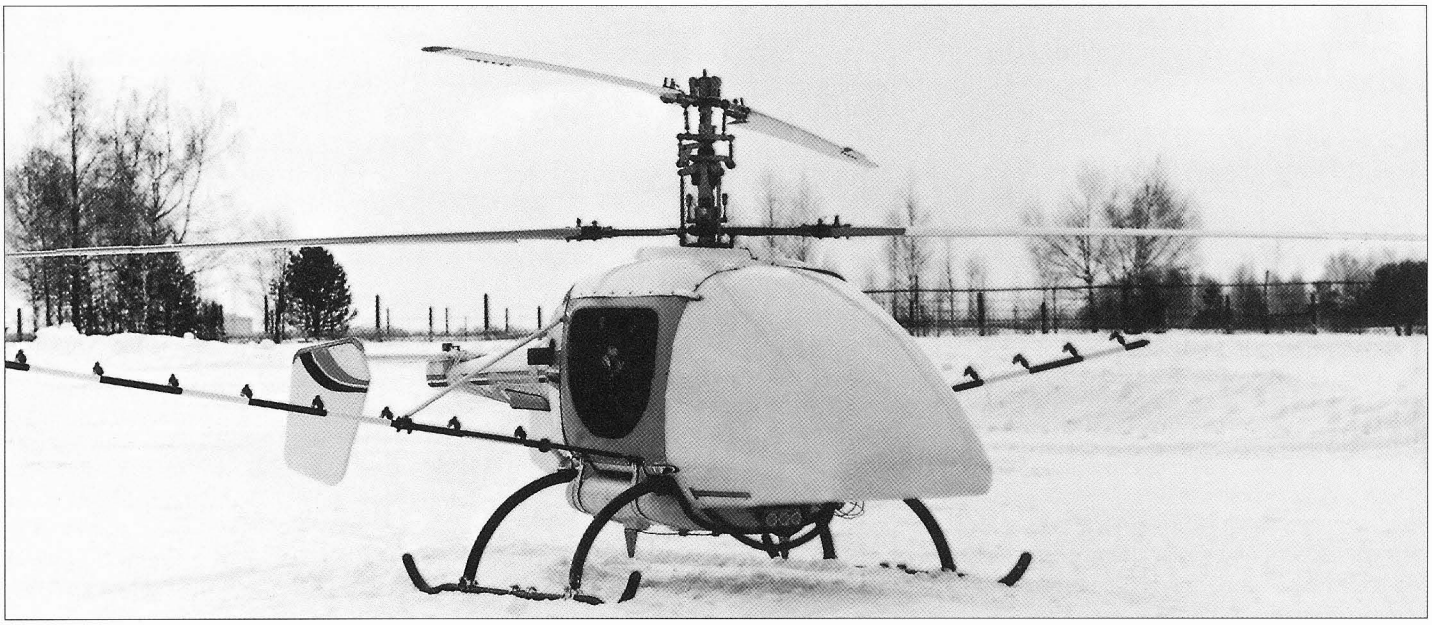
Kamov Joins the Game

Ka-37 Agromaster experimental pilotless helicopter

In the early 1990s the helicopter design bureau named after its founder Nikolay Il'yich Kamov ventured into the field of UAV design. Development of the Ka-37 Agromaster experimental remote-controlled agricultural helicopter started in 1991. Actually this was not a real agricultural UAV; the helicopter was intended for demonstration purposes only, simulating the operation of the mission equipment by atomising pure water through the spraybars.

The ADP passed the in-house review stage in 1992. A prototype was built in that same year, making its maiden flight in 1993. As one might imagine, the Ka-37 utilised the Kamov OKB's trademark contra-rotating layout with a twin-fin tail unit, the only departure from tradition being that the rotors were two-bladed, not three-bladed – such a compact and lightweight aircraft did not need three-bladed rotors.The chosen layout minimised the inertia forces, thereby improving manoeuvrability, and reduced the weight of the control system runs. The aerodynamic symmetry of the 'contra-rotating Kamov' and the absence of cross-links between the control system channels (as found on a conventional helicopter with a tail rotor) made it possible to develop a dependable automatic flight control system (AFCS) with simple software.

The Ka-37's airframe was made of composites and aluminium alloys; it had a beam-type construction with frames and bulkheads. The elongated forward fuselage section (nose fairing) was made of GRP, the flat lower panel having a three-ply construction; it was attached to the centre fuselage section's forward mating bulkhead by four Camloc fasteners. The centre fuselage was the principal load-bearing structure resting on a tubular skid landing gear; it accommodated the powerplant and sundry aircraft system components. The rear fuselage was a tapered GRP-skinned tailboom attached to the centre fuselage section's rear mating bulkhead by four bolts; it carried the tail unit comprising a one-piece horizontal tail and trapezoidal one-piece fins having forward sweep.



Top and above: The Ka-37 prototype sits in the snow at the Kamov OKB flight test facility in Lyubertsy just outside Moscow's city limits. The spraybars and ventral chemical tank are clearly visible. Like Kamov's very first helicopters (the Ka-8 and Ka-10), the machine has two-stroke engines and a skid landing gear.

Above: The Ka-37 hovers in a wire mesh enclosure at Lyubertsy; the spraying gear has been removed. The engine cowling was not fitted for the initial flight tests.

The powerplant consisted of two 24.6-kW Samara Engine Design Bureau (SKBM) P-037 440-cc two-cylinder horizontally opposed air-cooled engines mated to the gearbox to form a single unit. Each engine had its individual fuel feed, cooling and ignition systems. From the common 13-litre (2.86 Imp gal) fuel tank the fuel was fed to the carburettors by gravity. The gearbox combined the torque of the two engines while reducing the engine crankshafts' maximum speed of 6,900 rpm to a maximum of 600 rpm for the output shafts. Engine torque was fed into the gearbox via overrunning clutches which automatically disengaged a failed engine when the crankshaft speed fell to 50% of the nominal value. The coaxial output shafts carried the rotor heads.

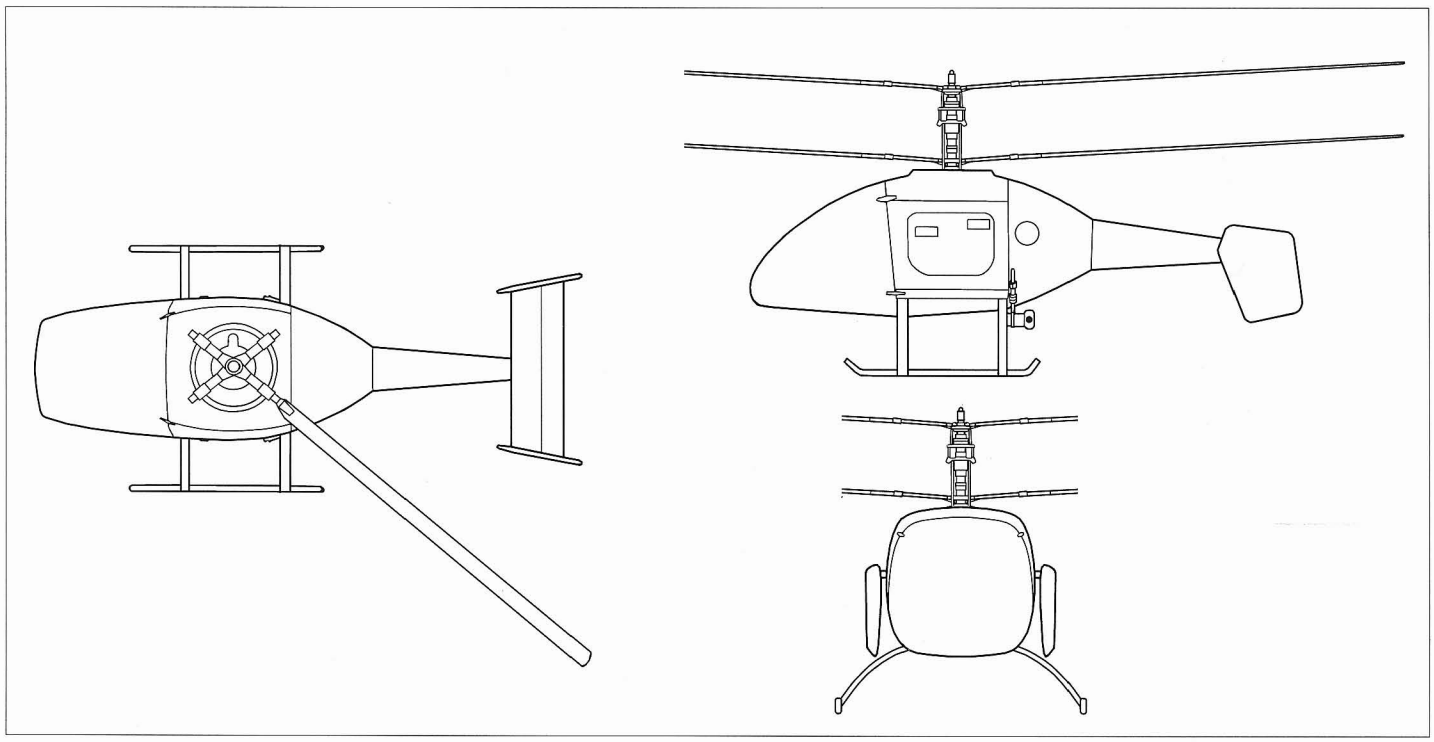
The rotor system, as already noted, comprised two-bladed contra-rotating rotors with individual swashplates. The rectangular blades were manufactured from natural and polymer composites. The rotor control mechanical components were similar to those of Kamov's 'full-size' helicopters.

27V DC power was supplied by a generator driven from the gearbox via an accessory drive shaft. Apart from the engines' ignition systems, the electrical system operated the agricultural equipment's chemical pump and shut-off cock, as well as the AFCS and the remote control system. For engine starting an external DC battery is connected to the aircraft via a power receptacle.

The AFCS and the on-board digital computer, together with other avionics which were integrated with the ground control station, issued commands to the electric control system servos, enabling the helicopter to lift off, hover at the required altitude, follow the desired trajectory and land at the pre-programmed location. The AFCS enabled both fully automatic (programmed) control, fully external control (radio control), and a combination of these two modes. The system's modules were located in the forward fuselage avionics bay. The AFCS was also integrated with the radio altimeter.

The electric control system servos were installed in the four blade pitch control circuits (one for each blade) and accommodated in the centre fuselage. The principles used in controlling the aerodynamic force vector created by the rotors and their torque forces was similar to that used on Kamov's 'full-size' manned helicopters.

Test and research work performed with the Ka-37 prototype and its ground control station (GCS) confirmed the feasibility of a



A three-view drawing of the Ka-37 minus agricultural equipment.

The Ka-137 full-scale mock-up in overall black finish at Lyubertsy (left) and in orange/red colours with EMERCOM of Russia titles and logo at one of the Moscow airshows (right). The latter livery includes 'Ka-137' and 'Maket' (mock-up) titles; the round dielectric 'window' over the mission equipment bay is very obvious.

pilotless helicopter intended for photo mapping, monitoring high-voltage power lines and oil/gas pipelines, broadcasting or relaying radio and TV signals, performing various survey and environmental research/monitoring work, assessing the scale of natural and environmental disasters and so on.

Ka-37S experimental pilotless helicopter

In 1996 the original Ka-37 evolved into the Ka-37S engine/avionics testbed forming part of an experimental heliborne system. Firstly, the two P-037 engines were replaced by a single 46-kW Austrian-built Hirth 2706 R06 two-cylinder air-cooled engine; this change facilitated the operation of the AFCS considerably. Secondly, a movable TV camera transmitting imagery to the GCS in real time was installed under the fuselage; thirdly, the avionics suite was upgraded by the addition of a satellite navigation system which was integrated with the AFCS.

The GCS featured an operator's workstation with controls, a personal computer with data presentation software, a TV system, radio control equipment, a power supply and communications equipment. On the ground the GCS communicated with the helicopter by radio and via cables; after take-off the radio channels were the only means of communication.

The Kamov Co. continued its efforts to bring the Ka-37 helicopter system up to a condition fit for series production for various customers.

Basic specifications of the Ka-37

Powerplant	2 x SKBM P-037
Engine power, kW	2 x 24.6
Length, rotors turning	2.88 m (9 ft 5$^{25}/_{64}$ in)
Height	1.64 m (5 ft 4$^{9}/_{16}$ in)
Width, less rotors	1.34 m (4 ft 4¾ in)
Rotor diameter	4.8 m (15 ft 9 in)
Normal take-off weight, kg (lb)	250 (551)
Payload, kg (lb)	50 (110)
Top speed, km/h (mph)	135 (83)
Service ceiling (dynamic), m (ft)	2,500 (8,200)

Ka-137 multi-role pilotless helicopter

The Kamov Co. retained the basic layout and many design features of the Ka-37 when developing the Ka-137 remote-controlled helicopter. The Ka-137 is intended for the following applications:

- tactical reconnaissance for the Ministry of Defence, the Federal Security Service, the Ministry of the Interior and similar agencies;
- engineering reconnaissance and NBC reconnaissance;
- urgent delivery of special cargoes;
- broadcasting or relaying radio and TV signals in dangerous environments (during natural disasters and the like);
- monitoring long power lines and pipelines;
- surveillance of important or restricted areas as part of security/counter-intelligence measures;
- border patrol, customs and police operations;
- environmental research/monitoring;
- ice patrol and fishery reconnaissance;
- fishery patrol (anti-poaching operations);
- fire protection patrolling of forests and peat bogs.

Development began in 1994 and the ADP was completed in 1995, followed by a full-scale mock-up the following year. The Ka-137 was the core of the MBVK-137 multi-role pilotless helicopter system (*mnogotsele**voy** bes-pi**lot**nyy vertol**yot**nyy **kom**pleks*) developed for operating and recovering these helicopters. Three versions of the MBVK-137 are

envisaged (vehicle-mounted, airliftable and shipboard); the airliftable version would utilise the Ka-32 utility helicopter as the delivery vehicle. The system includes a complement of two to five Ka-137s and the associated control and support equipment; the helicopters can be delivered to the system's operational location as an externally slung load under a regular helicopter.

The Ka-137 differs from the predecessor mainly in having an absolutely spherical fuselage with no tail surfaces or tailboom. Also, the skid-type landing gear is substituted with four separate cantilever spring struts tipped with pads; the struts are made of composites.

Structurally the fuselage consists of a framework (frames, load-bearing beams and a floor) and skin panels; the landing gear struts are attached at the beam/frame joints. The skin includes a number of detachable maintenance panels and cowlings. The fuselage is divided into a powerplant/gearbox bay, an electrics/avionics bay and a special equipment bay housing the mission equipment. The primary fuselage structure is made of aluminium alloys and polymer composites.

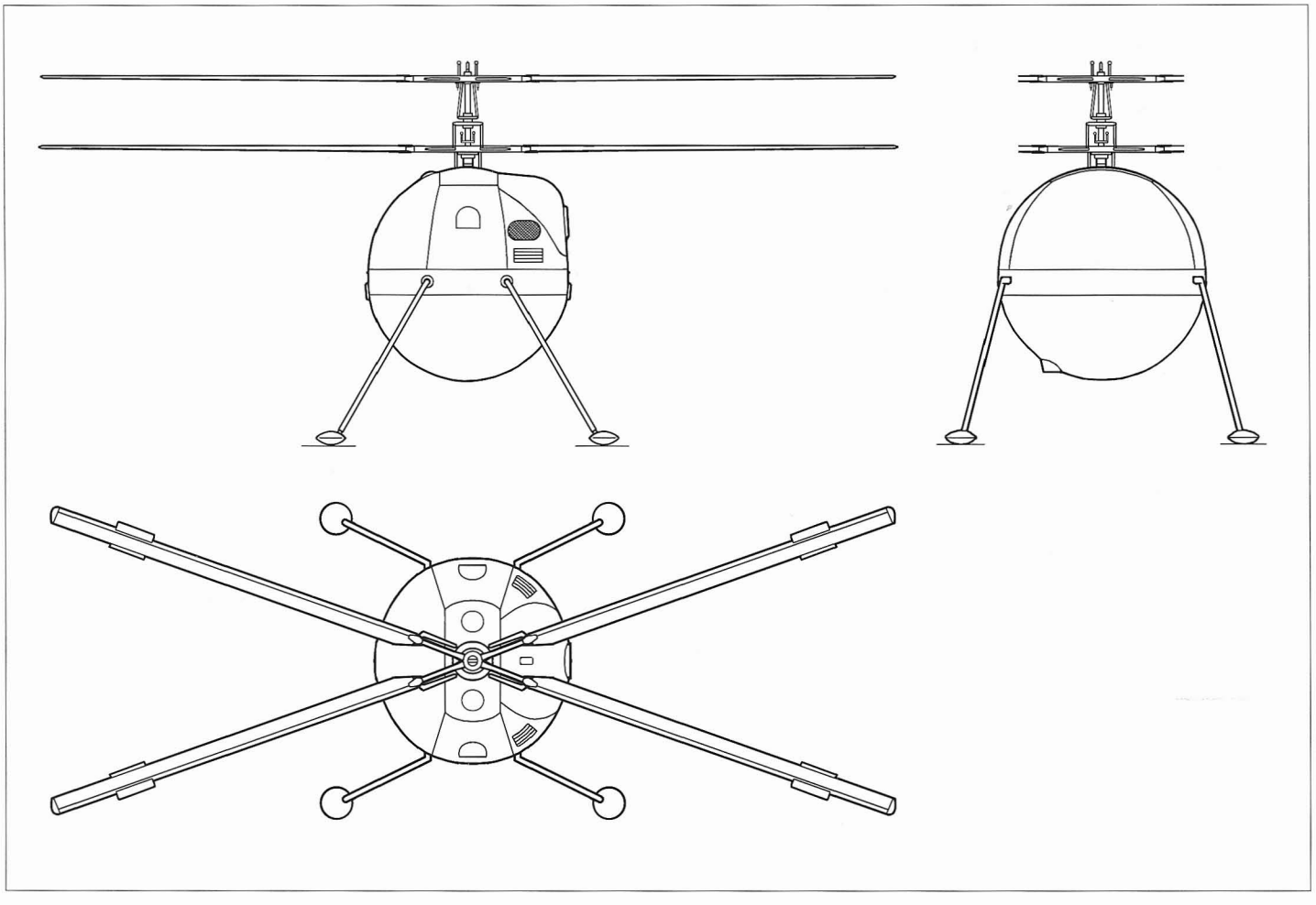
The powerplant/gearbox bay enclosed by a large cowling houses the gearbox with an accessory drive shaft for an AC generator, two fuel tanks, the rotor pitch control mechanisms and an electronic module. The engine is separated from the adjoining bays by firewalls. To ensure the correct CG position the mission equipment bay has been moved from the forward fuselage (in the case of the Ka-37) to the rotorcraft's axis. It is enclosed by a dished dielectric panel, the mission equipment and remote control system aerials being located externally.

The spherical shape of the fuselage has minimised inertia forces and made the wind direction less relevant to the helicopter's handling. This is especially important for a remote-controlled or automatically controlled rotorcraft which is to operate in turbulence and strong gusting winds of unknown direction. Given the equal aggregate engine power, the Ka-137's smaller fuselage cross-section ensures it higher flight performance and makes it less susceptible to battle damage when used for battlefield surveillance and target designation.

The rotor system, powerplant, electrics and other systems of the Ka-137 are similar to those of the Ka-37S. The Kamov Co. persistently works on refining the design, taking account of the experience gained in actual flights and in simulated flight in both normal and abnormal conditions. According to the customer's wish the Ka-137 can be outfitted with TV cameras or thermal imaging equipment, a radar, communications relay equipment and so on, as long as the weight does not exceed 80 kg (176 lb).

Basic specifications of the Ka-37

Powerplant	1 x Hirth 2706 R05
Engine power, kW	2 x 47.8
Length (measured by the landing gear)	1.88 m (6 ft 2 in)
Height	2.3 m (7 ft 6$^{5}/_{64}$ in)
Rotor diameter	5.3 m (17 ft 4$^{21}/_{32}$ in)
Normal take-off weight, kg (lb)	280 (620)
Payload, kg (lb):	
normal	50 (110)
maximum	80 (176)
Top speed, km/h (mph)	175 (108)
Cruising speed, km/h (mph)	145 (90)
Hovering ceiling, m (ft)	2,900 (9,510)
Service ceiling (dynamic), m (ft)	5,000 (16,400)
Maximum endurance with a normal payload at 50 km (31 miles) from base, hours	4.0
Range with a normal payload, km (miles)	530 (329)



A three-view of the Ka-137

Chapter 5

Current Programmes

At the 45th Paris Air Show in 2003 Russia displayed next to no unmanned aerial systems – in stark contrast to the Western participants who had plenty of UAVs to offer. Two months later, however, Russia's own MAKS-2003 airshow (19th-24th August 203) made up for this poor performance; the visitors were treated to the latest Russian UAV technologies.

Obviously Russia has indeed changed its attitude towards unmanned aerial systems, and what was once dismissed as 'small fry' is now regarded as a promising area of aircraft technology. What better testimony to this could there be than the words of Russian Air Force Commander-in-Chief Col. Gen. Vladimir Mikhaïlov, who said in a press interview at the MAKS-2003 that 'in the past years unmanned aerial vehicles have indeed been somewhat underrated on Russia and now this error is being corrected fast'. This chapter deals with some of the latest UAVs developed in Russia.

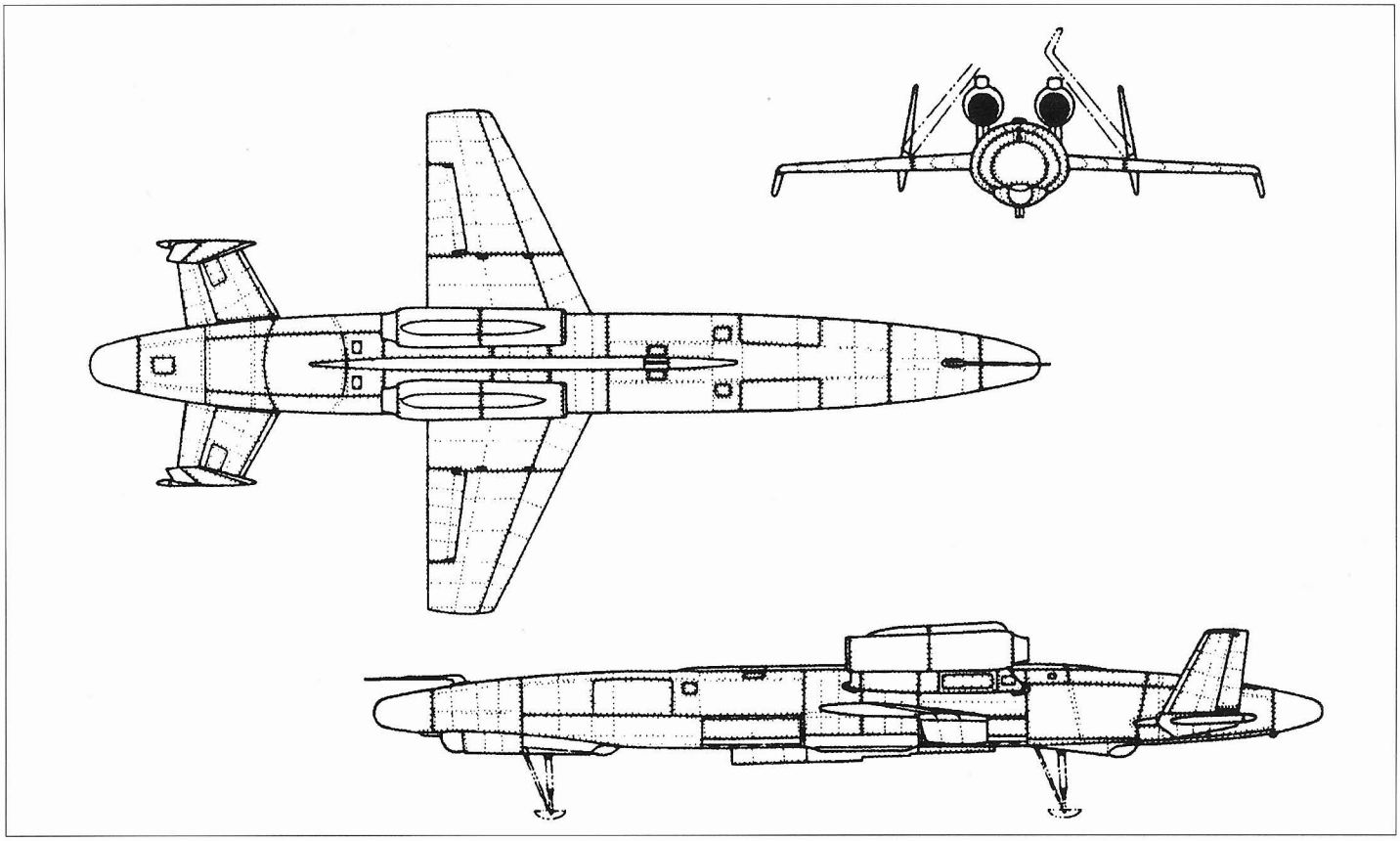
Korshoon unmanned combat aerial vehicle

Actually this not a current programme, but it deserves mention all the same. As noted in Chapter 2, in the mid-1970s OKB-51 headed by Pavel Osipovich Sukhoi was instructed to start work on a UCAV called Korshoon (Kite; no alphanumeric designation is known) – a mini-bomber for use against particularly heavily protected targets. N. S. Chernyakov headed the development effort.

The Korshoon was quite a large aircraft, with an overall length of 15.6 m (51 ft 2$^{11}/_{64}$ in) and a wing span of 8.25 m (27 ft 0$^{13}/_{16}$ in). It had an oval-section fuselage somewhat flattened from below, with a large nose radome; a shallow ventral fairing just aft of it incorporated an optoelectronic system turret and the nose landing gear unit. The moderately swept low aspect ratio wings of trapezoidal planform had slight anhedral from the roots and downward-canted tips, folding upwards for storage. The tail unit had twin swept fins and rudders canted inward, the low-set horizontal tail having zero dihedral. Two small turbojet engines were mounted on short pylons above the centre fuselage. The aircraft had a parachute recovery system and a tricycle landing gear; all three units retracted aft, featuring dished pads. The warload – up to 500 kg (1,100 lb) – was carried on a single centreline pylon located near the CG.

The aircraft was to be launched from a sloping ramp by means of rocket boosters. It would be controlled from a specially modified Su-24 tactical bomber known as the PUN-24 (*poonkt oopravl**en**iya navi**gah**tsiyey* – navigation control station), the weapons systems officer sitting in the right seat being replaced by a UCAV control operator.

However, in 1983, when prototype airframe subassemblies were already being manufactured at the Sukhoi OKB's experimental shop, the CofM Presidium's Commission



Looking like something out of Star Wars (at any rate, it did when it was developed), the Korshoon UCAV was an interesting design. Too bad the Sukhoi OKB was denied the chance to build and fly it.

on Defence Industry Matters (VPK) ordered all work to be stopped. The government's decision was that the Tupolev Aviation Scientific & Technical Complex was in a better position to design the UCAV. Curiously, while being a totally unrelated design, the Tupolev UCAV (the '300') bore the same name, Korshoon.

BAS-62 unmanned aerial system:

S-62 high-altitude UAV (project)

Lately the Sukhoi OKB has again challenged the Tupolev OKB's position as the nation's top 'UAV maker' and taken the lead in the development of high-altitude unmanned aircraft with a long endurance. Since the late 1990s it has been working on the BAS-62 unmanned aerial system (*bespi**lot**naya aviat-si**on**naya sis**tem**a*), a high-flying communications relay and surveillance/monitoring platform supporting the operations of various ministries and government agencies.

The system is built around the S-62 UAV. If the main performance target – the ability to loiter at an altitude of 20,000 m (65,620 ft) for 24 hours – is met, the aircraft will be able to perform uninterrupted round-the-clock monitoring of large areas. According to preliminary estimates, a single S-62 will be able to cover an area of about 1,130,970 km² (436,668 sq miles) – that is, a circle with a 600-km (372-mile) radius.

Unlike its nearest Western equivalent – the Northrop Grumman RQ-4A Global Hawk – and other heavy UAVs, which require paved runways, the S-62 is suitable for operation from ad hoc field pads as long as there is at least 600x600 m (1,970x1,970 ft) of open space available. The UAV is launched from a catapult and makes use of an arrester wire installation for landing, being equipped with an arrester hook.

The S-62 high-altitude UAV utilises the tail-first layout with ultra-high aspect ratio wings and twin fuselages. The wing centre section carries twin vertical tails, with an engine nacelle on a short pylon mounted in between. The airframe is made largely of composites. The chosen layout gives the S-62 excellent aerodynamics, with a lift/drag ratio approaching that of competition sailplanes.

The powerplant consists of two 1,700-kgp (3,750-lbst) RD-1700 turbofans developed by the Moscow/Tushino-based TMKB *So**yooz*** (***Too**shinskoye **mo**tor**no**-kon**strook**torskoye **byu**ro* – 'Union' Tushino Engine Design Bureau) jointly with the Central Aero Engine Research Institute (TsIAM – *Tsen**trahl'**nyy insti**toot** aviatsi**on**novo **mo**tor**o**stroy**eni**ya*). The engines are installed side by side in the abovementioned nacelle above the wing centre section. Provision is made for in-flight refuelling in order to increase endurance.

Two versions of the basic design are envisaged: the S-62A optimised for aerospace monitoring and the S-62B designed for overland and overwater surveillance. The former version's mission equipment comprises radar and optical suites. The radar suite is based on the *Rezo**nans*** (Resonance) metre-waveband search radar capable of detecting and tracking various types of aerial targets (heavy commercial and military aircraft, light and business aircraft, fast jets and all kinds of helicopters) at up to 500-600 km (310-372 miles), depending on the target's RCS. The Rezonans radar is characterised by the ability to perform continuous 360° surveillance; this, and the long detection/tracking range, renders it markedly superior to any Western counterpart.

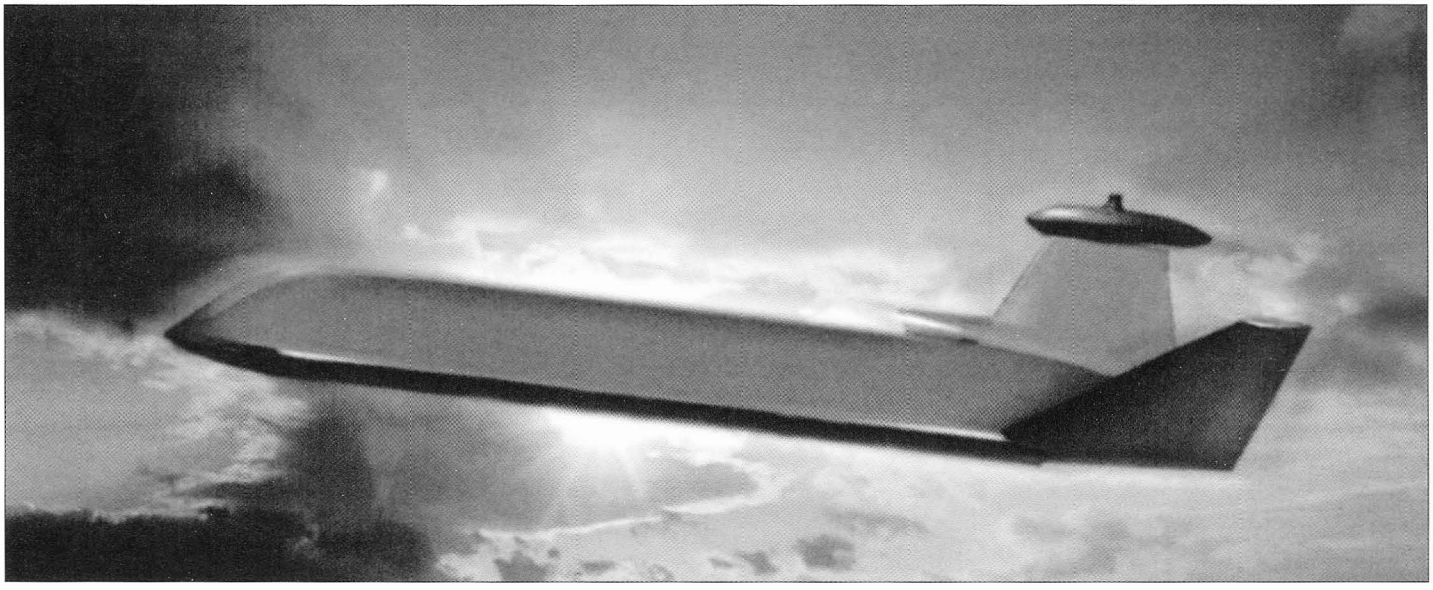
The S-62A's optical suite allows aerial targets to be identified more precisely and their co-ordinates to be determined more accurately. With the UAV loitering at 20,000 m, the optical suite makes it possible to keep an eye on aircraft flying above the clouds up to 800 km (496 miles) away.

The S-62B is to be fitted with a side-looking synthetic aperture radar (SAR), an opto-electronic system and other special equipment (for example, a system for detecting leaks in underground pipelines). This mission equipment fit enables highly efficient multi-spectrum scanning of the ground or water surface.

The flight avionics are common for all versions of the S-62. It comprises a precision inertial/satellite navigation suite, an automatic flight control system, remote control equipment, a computer, a data recording and retrieval system and IFF and air traffic control (ATC) transponders.

The S-62 is to operate in automatic mode, following a mission profile loaded into the AFCS. The high altitude at which the UAV will operate makes sure it remains within direct radio visibility of the mobile control, communications and data processing unit (500-600 km) at all times. The use of another UAV equipped as a communications relay platform increases the control/communications range (and, in the case of the S-62A, the target detection range) considerably to 1,000-1,500 km (620-930 miles).

Because the UAV is fitted out with costly mission equipment, the concept of the BAS-62 system presupposes high operational reliability – at least on a par with commercial airliners. The factors providing for high reliability include the UAV's high lift/drag ratio: in the event of a double engine failure the S-62 can glide from its operational altitude to virtually any location up to 600 km away, which pretty much guarantees that a safe



An artist's impression of the Sukhoi S-62 UAV, which unfortunately gives no clear idea of the aircraft's appearance.

landing place is found. Also, the extremely high operational altitude and the concept of operating the UAV from field locations virtually preclude the possibility of a collision with a manned aircraft.

The designers of the BAS-62 have paid special attention to ergonomics and to improving the system's maintainability, making it 'user-friendly'. This is pretty much in line with world standards; on the other hand, Western companies engaging in UAV design find it hard to understand some of the requirements specified by the Russian standards, such as operating temperatures down to –50°C (–58°F).

The as-yet non-existent S-62 UAV is already offered for export with a provisional price tag of US$ 7 million, while the complete BAS-62 unmanned aerial system (including three UAVs) would cost about US$ 30 million.

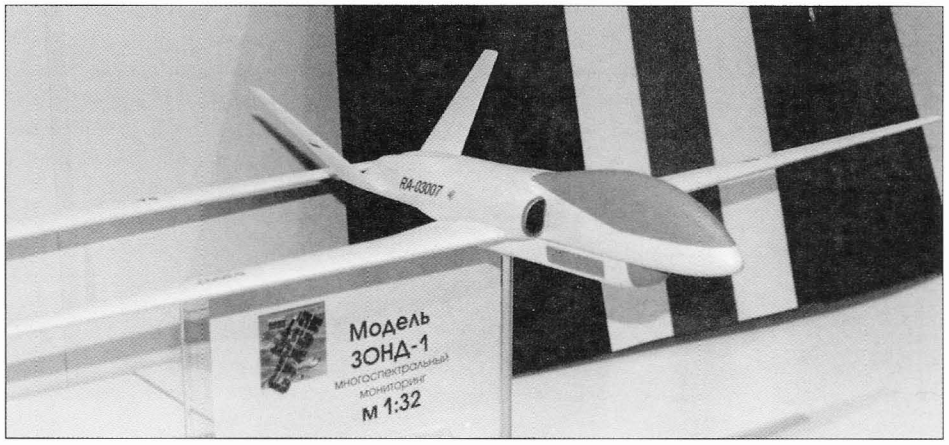
Basic specifications of the BAS-62 unmanned aerial system (as per ADP documents)

Length overall	14.4 m (47 ft 2⅝ in)
Height (fuselage axis level)	3.0 m (9 ft 10¾ in)
Wing span	50.0 m (164 ft 0½ in)
Normal take-off weight, kg (lb)	8,500 (18,740)
Payload, kg (lb)	1,000 (2,200)
Cruising speed	Mach 0.45
Flight altitude, m (ft)	20,000 (65,620)

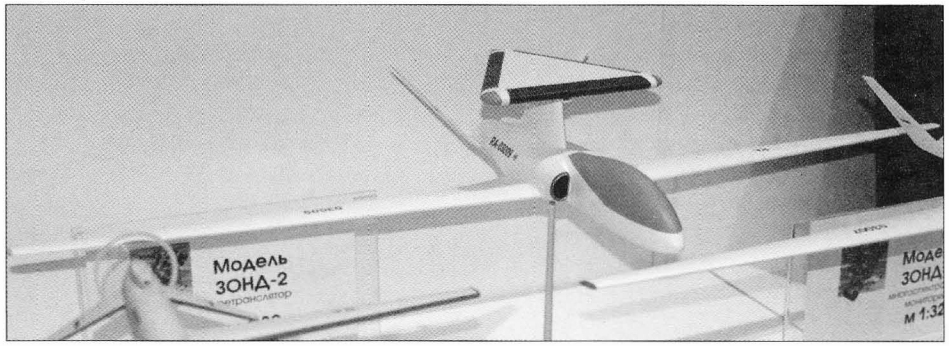
Zond UAV family (project)

At the MAKS-2003 airshow the Sukhoi OKB unveiled, in model form, another family of UAVs designed for long-duration missions and provisionally designated Zond (Probe). Two of the three aircraft in the family – the Zond-1 and the Zond-2 – are two versions of the same design which is in the same class as the Northrop Grumman RQ-4A Global Hawk. In fact, they bear a striking resemblance to the Global Hawk, featuring a bizarrely bulged forward fuselage ('thick head'), two turbofans buried in the rear fuselage, ultra-high aspect ratio wings and a butterfly tail; the most obvious difference is that the Russian UAV's engines breathe through individual lateral air intakes instead of a common dorsal intake.

The Zond-1 is intended for monitoring developments on the ground by means of long-range operations (LOROP) TV cameras, thermal imaging equipment and a side-looking airborne radar (SLAR), all of which are housed in a large ventral canoe fairing. The Zond-2 is an airborne early warning (AEW) platform and is even more bizarre, featuring a 360° search radar in a fixed pylon-mounted dorsal fairing shaped like an equilateral triangle with rounded apexes (that is, there are three antenna arrays, each covering a sector of 120°). In all other respects the two aircraft are identical.



Above: Russia's answer to the Global Hawk is Sukhoi's Zond-1. This 1/32nd scale model was displayed at the MAKS-2003 airshow. No, this is not a cockpit canopy but a huge opaque fairing over SATCOM gear.



Above: The Zond-2 based on the same airframe is an unmanned AEW platform with a radar array in a fixed pylon-mounted triangular fairing.

The Zond-3 is a much smaller UAV with an undernose sensor turret. It also has a dielectric 'canopy' over SATCOM gear, but this is flush with the fuselage top.

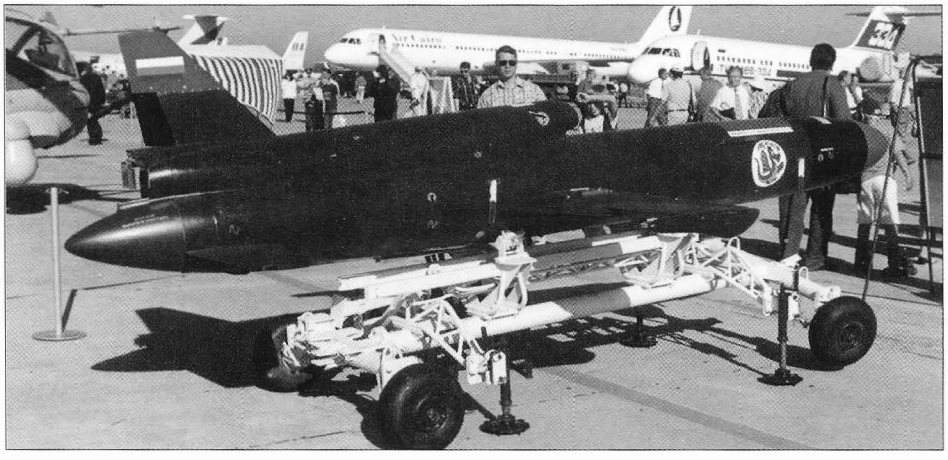
The third member of the family, the Zond-3, is a totally unrelated design. It is a much smaller vehicle which bears more than a passing resemblance to another American UAV, the General Atomics MQ-9 Predator B. Like the latter, it is powered by a turboprop engine driving a pusher propeller and has an inverted butterfly tail and a retractable wheel landing gear.

A common feature of the Zond family – the large dielectric fairing forming the upper part of the forward fuselage – suggests that the UAVs are equipped with satellite communications (SATCOM) gear for transmitting intelligence data to the users. This feature helps to increase the UAVs' range and operational autonomy.

Dan' target drone

In the early 1990s the Kazan'-based Sokol OKB developed the M-932 Dan' target drone as a follow-on to the La-17MM for emulating various aerial vehicles, including cruise missiles. The name stands for 'tribute' or 'contribution' – or, if you like, 'Dane-geld'. (As Rudyard Kipling wrote: *'We never pay **any** one Dane-geld, // No matter how trifling the cost; // For the end of that game is oppression and shame, // And the nation that plays it is lost!'* Obviously the name of the drone hinted at

Above: The Dan' target drone had its public debut at a defence fair held in Nizhniy Novgorod in 1993. It is seen here beside a locally built MiG-29UB combat trainer; note the protruding engine jetpipe.



'being under contribution' to the SAM units and giving them 'something to kill'.)

The Dan' is a compact aircraft with a circular-section fuselage and straight mid-set wings and horizontal tail. The swept vertical tail is mounted on top of a cylindrical superstructure which begins with a quasi-elliptical air intake feeding a 120-kgp (265-lbst) MD-120 turbojet via a short straight duct. All tail surfaces have inset control surfaces. Two tracer flares are mounted on the port wing trailing edge at the tip, while the starboard wingtip carries an equipment pod.

The MD-120, which was developed by the Moscow-based *Granit* (Granite) Machinery Design Bureau specifically for UAVs, has a two-stage compressor with an axial first stage and a centrifugal second stage, an annular combustion chamber and a single-stage axial turbine; the spool bearings are lubricated by the fuel. Starting is by compressed air from an outside source impinging on the compressor blades. The engine is 1.29 m (4 ft 2$^{25}/_{32}$ in) long, with a diameter of 0.265 m (10$^{7}/_{16}$ in), and weighs 35 kg (77 lb).

The Dan' has a combined autonomous/radio control system enabling it to operate as a drone or as an RPV. It is launched from a catapult mounted on a tracked chassis; should it escape destruction, a parachute recovery system housed in the tailcone comes into play.

The Dan' is produced in quantity for the Russian Air Force by the Strela Federal State Unitary Enterprise in Orenburg which previously built the La-17. Starting in 1993, it has been exhibited at various local and international airshows.

Top and above: The Dan' on its ground handling dolly at the MAKS-2001 airshow at Zhukovskiy. All examples seen to date are red overall with a green/black nose and carry a dragon logo on the fuselage. This one appears to be engineless.

Basic specifications of the Dan' target drone

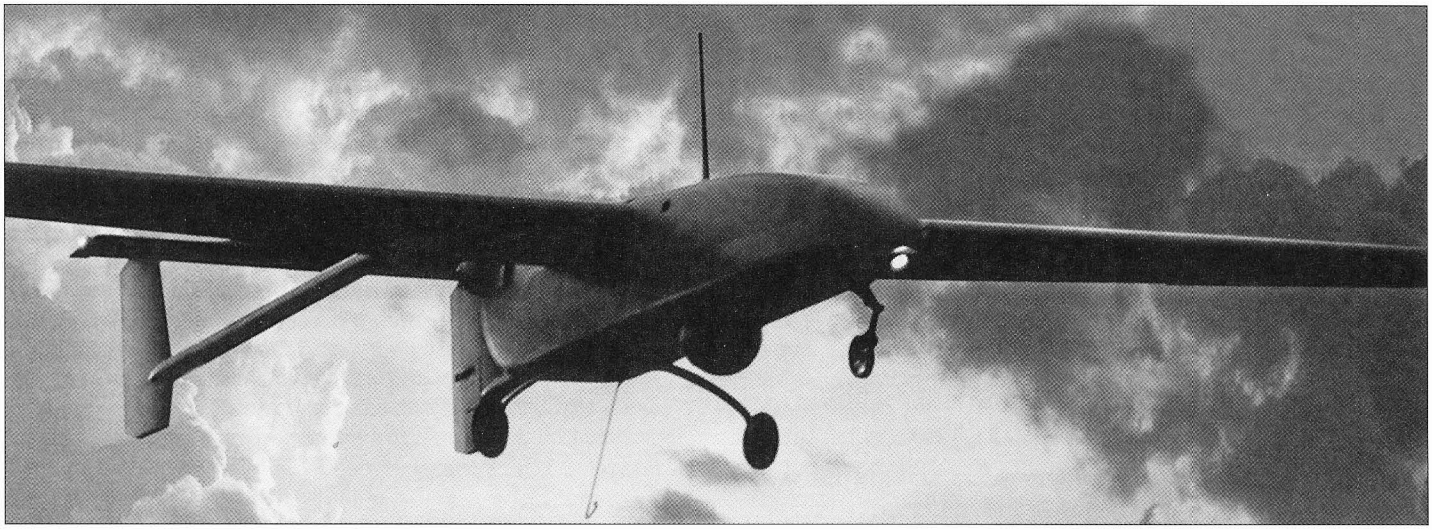
Length overall	4.65-4.9 m (15 ft 3 in – 16 ft 0²³⁄₃₂ in)
Height (fuselage axis level)	0.815 m (2 ft 8 in)
Wing span	2.683 m (8 ft 9⅝ in)
Launch weight, kg (lb)	345 (760)
Cruising speed, km/h (mph)	300-710 (186-441)
Flight altitude, m (ft)	50-9,000 (164-29,530)
Endurance, minutes	25-40
Maximum no.of launches	10
G limits	+9/–3

Irkut Corporation unmanned aerial survey/monitoring system (project)

At the MAKS-2003 airshow the Irkutsk-based Irkut Corp. (formerly the Irkutsk Aircraft Production Association) publicly unveiled a new advanced multi-role unmanned robotic aerial system, which it offered to various ministries and agencies. The system is primarily designed for the following applications:

- monitoring large territories during prolonged periods;
- measuring chemical pollution and radioactive contamination levels;
- assessing the damage caused by man-made or natural disasters;
- transmitting TV and infra-red imagery of the terrain in real time to the control centre and remote users;
- pinpointing the exact location of the objects being reconnoitred.

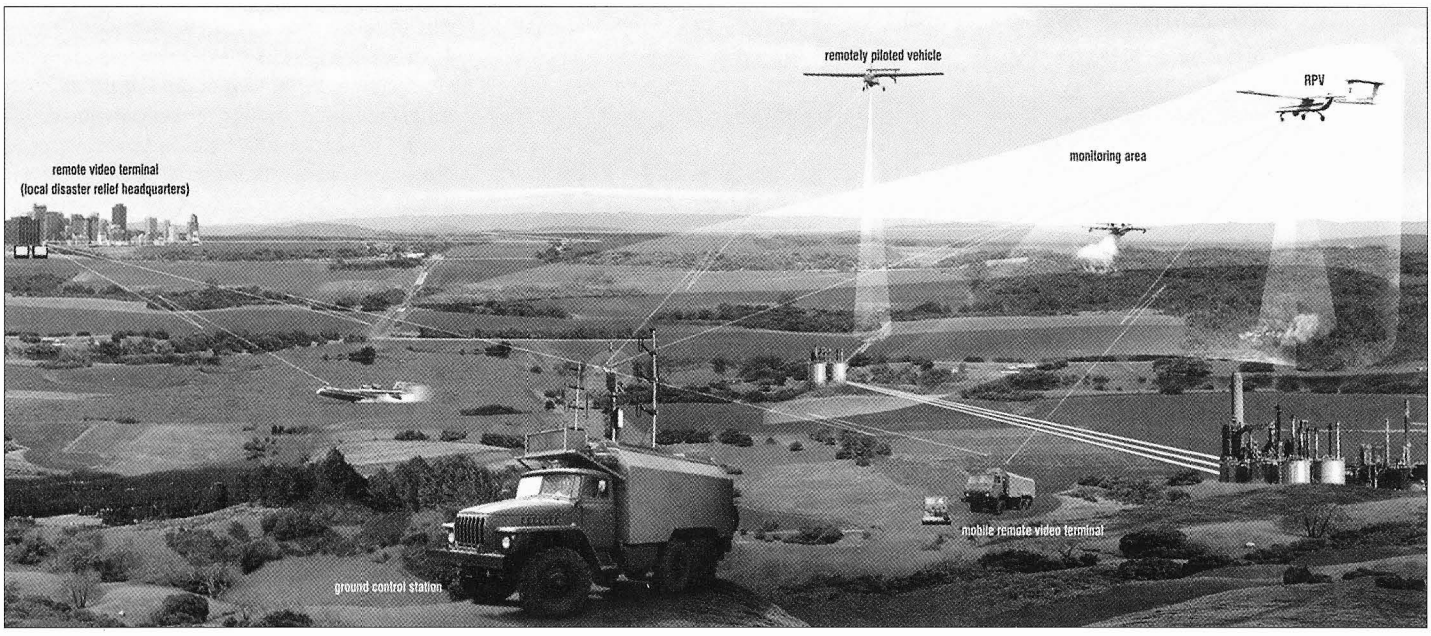
Among other things, the Russian Ministry of Emergency Control (EMERCOM) responsible for rescue and relief operations during natural disasters and major accidents took an interest in the new system, intending to use it for fighting forest fires alongside Antonov



Above: An artist's impression of the Irkut Corporation UAV from a company ad; note the deployed arrester hook.

Right: The prototype seen in a test flight in 2004.

Below: This picture shows how the Irkut Corporation UAV can be used to coordinate the actions of other aircraft (such as Be-200ChS firebombers) during disaster relief missions. The ground control station and the mobile remote video terminal are based on the Ural-4320 and the KamAZ-4310 respectively.



An-3T and Beriyev Be-200ChS aircraft, Mil' Mi-8MTV-1 and Mi-26T helicopters and other assets. The UAV was to patrol the area of the fire, supplying 'target information' to the waterbombers in real time and helping to assess the effect of the fire-fighting operations.

Like many light UAVs, the unnamed machine utilises a twin-boom layout with shoulder-mounted straight wings, an aft-mounted piston engine driving a pusher propeller and a fixed tricycle landing gear with cantilever spring struts. It is capable of day and night operation, supplying TV and IR imagery round the clock while up to 150 km (93 miles) away from the base. The image may also be transmitted over a distance of up to 30 km (18.6 miles) to compact remote video terminals which may be man-portable or installed on an automobile, a helicopter or elsewhere. If the UAV operates far away from the recipients of the information it generates (up to 200 km/124 miles) or flies at low level, another UAV or a helicopter is to serve as a communications relay platform.

The system comprises the following:

- four UAVs, two of which would be flying sorties and a third standing in hot reserve while the fourth would be grounded for maintenance;
- a mobile ground control station;
- ground data link equipment;
- four mobile remote video terminals;
- ground support and maintenance equipment.

The system can be quickly dismantled and packed into airliftable containers, then deployed just as rapidly, which makes for its high mobility. The UAV can operate from hard-packed earth, as well as from concrete or tarmac; the airstrip needs to be at least 300 m (990 ft) long and 10 m (33 ft) wide. If obstacles around the landing strip preclude normal conventional take-off and landing (CTOL) operations, the UAV can be launched from a catapult and use a parachute recovery system for landing. Operation of a single UAV requires a support crew of four; with two UAVs in operation, this number increases to five persons.

The vehicle can operate either in drone mode (controlled automatically by a pre-loaded programme) or in radio control mode; either way, the take-off and landing are always controlled by radio. Currently, however, work is under way on a system enabling fully automatic take-off and landing.

The fire-fighting version is equipped with a thermal imager having a resolution of 0.5 m (1 ft 7 1/16 in). This makes it possible to reveal even hidden fires, such as underground peat fires which are hard to put out.

In order to save time the Irkut Corp. made use of imported technology to a certain extent; in particular, a licence to build the airframe was acquired from Israel Aircraft Industries (IAI). The example displayed at the MAKS-2003 was a full-scale mock-up; the first flight of the real thing took place as planned in the autumn of that year. According to Irkut, the first production UAVs were to be delivered to EMERCOM as early as April-March 2004; however, no actual deliveries have been reported.

Currently the Irkut Corp. is working on a mini-UAV with a take-off weight of 50 kg, as well as on a heavier UAV capable of carrying a mission equipment load of 150-250 kg (330-550 lb).

It has to be said that UAV development is an important part of Irkut's corporate strategy formulated four years ago. This was also pronounced to be one of the key activities of the new holding company uniting the Irkut Corp. and the Yakovlev OKB; the establishment of this company was officially announced at the MAKS-2003.

Basic specifications of the Irkut UAV

Length overall	4.0 m (13 ft 1½ in)
Wing span	6.0 m (19 ft 8⅞ in)
Take-off weight, kg (lb)	200 (440)
Payload, kg (lb)	50 (110)
Fuel load, kg (lb)	50 (110)
Top speed, km/h (mph)	200 (124)
Cruising speed, km/h (mph)	150 (93)
Loitering altitude, m (ft)	6,000 (19,685)
Maximum range, km (miles)	1,200 (745)
Maximum endurance	14 hours
Real-time TV imagery transmission range, km (miles)	150 (93)

GrANT unmanned aerial reconnaissance system

The ***Novik*** – ***Dva****dtsat'* ***per****vyy vek* (Novik – 21st Century) innovation company, a fairly young enterprise specialising in UAV design, presented an improved version of its GrANT unmanned aerial reconnaissance system designed for real-time aerial reconnaissance at the MAKS-2003 airshow. The original version had made its debut at the MAKS-2001 from 14th to 19th August 2001. (The Russian word 'novik', derived from the adjective ***novyy*** (new), was used in the 17th century to denote a young and upward-mobile nobleman who had newly entered military service.)

The system comprises the following:

- two mini-UAVs;
- a mobile control centre based on the UAZ-3962 cross-country minibus and capable of controlling the operations of four RPVs at a time;
- a TLV based on the UAZ-3303 0.45-ton four wheel drive 'truckster'.

The GrANT mini-UAV is equipped with a TV camera and a data link transmitter; the signal is recorded in digital format aboard the control station and can be delivered to the user on CD-ROM or via the Internet. The system's effective combat radius is 70 km (43.5 miles).

The UAV is, in effect, a model of the kind that radio-controlled model enthusiasts build and fly. The all-up weight is only about 20 kg (44 lb), which obviates the need for solid-fuel rocket boosters; the catapult installed on the TLV is a simple mechanical device utilising the energy of a falling weight pulling a cord. After completing the mission the RPV glides to a landing.

The GrANT's small size, the use of dielectric structural materials and some aspects of the powerplant ensure that the RPV has a low radar, heat and acoustic signature. The UAV has a design life of 100 flights. It can perform automatic flight to the target and back, transmitting video imagery and indicating its position with an accuracy margin of a couple of metres (the UAV's co-ordinates are determined by a differential satellite navigation system). The operator sitting in the control centre is able to alter the flight programme, changing the UAV's course; he can also select one of the three TV cameras carried by the UAV and make repeated passes over the target if necessary. The GrANT makes use of an algorithm called, rather puzzlingly, the Chistyakov Trawl; this means simply that the target is viewed consecutively by three gyrostabilised TV cameras with different fields of view.

Despite the system's 'peaceful' name (the acronym GrANT is deciphered as *grazh****dahn****skiy* ***a****erodina****mich****eskiy nablyu****dah****tel' televizi****on****nyy* – 'civilian aerodynamic (*sic*) TV observer'), the company is touting primarily the system's military applications. QED: the old Soviet habit of adapting everything for military purposes lives on; as a line from an old Soviet song goes, *we're peace-loving people, but our armoured battle train is right there in a siding* (and ready for action – *Auth.*). On the other hand, according to the designers, the GrANT is almost ten times cheaper to operate than other unmanned aerial reconnaissance systems currently available, which renders its commercial use economically viable.

BRAT-1 and BRAT-2 reconnaissance mini-UAVs

Another product of the *Novik – Dvadtsat' pervyy vek* innovation company which was on show at the MAKS-2003 rejoices in the name BRAT. This inevitably draws laughs from Russians and English speakers alike, albeit for different reasons. The Russian word 'brat' (pronounced *braht*) means 'brother'; however, once again here we have an acronym standing for ***blizh****niy* *raz****ved****chik* ***a****erodi-na****mich****eskiy televizi****on****nyy* – 'short-range

aerodynamic TV reconnaissance vehicle'. Actually there are two 'brothers' – the recoverable BRAT-1 with a 30-km (18.6-mile) radius of action and the expendable BRAT-2 with an operational range of 90 km (55 miles). Considering the vehicle's diminutive size, this is a truly impressive figure, but it is achieved by making the mission a one-way trip and by using a taller transmitter antenna at the command post to make sure the signal gets through.

Incidentally, the fact that there are two varieties are the main reason why the name of the system amuses Russians immensely. It evokes associations with the Russian *Brat* motion picture and its sequel, *Brat-2* – both of them action films about two brothers in the flesh and brothers-in-arms (or, to be precise, bandits-in-arms) who start off locally and end up going to the USA to... well, to wreak justice.

The command module may come in man-portable or vehicle-mounted versions, the latter variety being suitable for installation in a jeep. The mobile control station of the GrANT unmanned aerial reconnaissance system can also be used. Besides the command module, the BRAT system comprises a supply of UAVs which are packed into portable containers with two 'brothers' apiece.

The UAV itself weighs a mere 3 kg (6.6 lb), which means it can be easily launched by hand; it utilises the normal aerodynamic layout and has a tractor propeller. The machine is 1.0 m (3 ft 3⅝ in) long, with a wing span of 1.9 m (6 ft 2¹³⁄₁₆ in). The BRAT is capable of flying the same missions as its larger GrANT stablemate, albeit at much shorter range. The avionics suite, which is kept as simple as the mission will allow, comprises a GLONASS (*glo**bahl'**naya navigatsi**onnaya* ***spoot**nikovaya sis**tem**a*, the Soviet equivalent of the GPS global positioning system) satellite navigation receiver and two TV cameras (one with a normal lens and the other with a wide-angle lens) utilising the Chistyakov Trawl algorithm; it was developed by a telecommunications enterprise in Molodechno, Belorussia.

A small batch of BRAT UAVs was reportedly delivered to an undisclosed foreign customer.

Granit-F reconnaissance mini-drone

Other mini-UAVs present at the MAKS-2003 included the Granit-F vehicle created by the Moscow-based Impul's company. It is extremely similar in design to the BRAT described above and is intended primarily for reconnaissance operations in support of small Army units and special forces (commando) groups. Civil applications include pipeline and power line patrol, monitoring the condition of roads and railroads, search and rescue operations, agricultural and forestry protection work, and ecological survey of land, bodies of water and the atmosphere.

The Granit-F system comprises the following components:

- a mini-drone of the same name;
- a portable controller;
- a laptop computer used for loading the mission profile into the UAV's control system and processing the intelligence data after the mission;
- a data link system for transmitting the TV imagery to the control centre.

All components are carried in compact backpack-type containers.

The Granit-F belies its name, since the launch weight again is only 3 kg. The drone is powered by a battery-fed electric motor and carries a payload of up to 300 grams (10.59 oz), including a colour digital camera. A GLONASS satellite navigation receiver is fitted for navigation and providing accurate co-ordinates with an accuracy margin of a few metres.

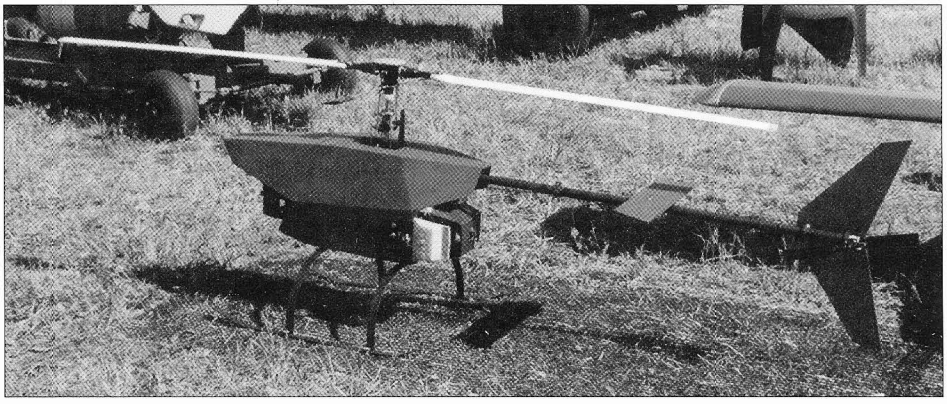
The drone is launched by hand, and mission preparation time is just ten minutes. The flight proceeds in accordance with the programme loaded into the on-board computer. Upon return and recovery the exhausted battery is replaced by a fresh one and a new programme is loaded, and the Granit-F is ready for the next sortie in five to ten minutes. The drone's extremely compact size and low radar, heat and acoustic signature give it good chances of survival when used in a combat scenario.

Basic specifications of the Granit-F drone

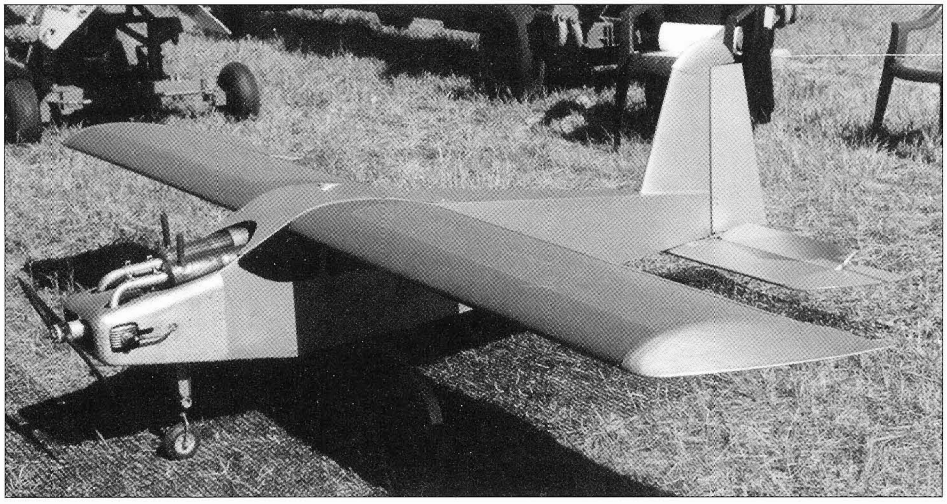
Take-off weight, kg (lb)	3 (6.6)
Payload, kg (lb)	0.3 (0.66)
Maximum endurance	30 minutes
Service ceiling, m (ft)	1,000 (3,280)
Top speed, km/h (mph)	100 (62)
Cruising speed, km/h (mph)	150 (93)
Operational radius, km (miles)	10 (6.2)
Maximum distance between operator and command centre, km (miles)	30 (18.6)

GMKB Raduga/MAI UAV programmes

Starting life in 1953 as a section of Artyom I. Mikoyan's OKB-155 fighter design bureau, OKB-2-155 headed by Aleksandr Ya. Bereznyak specialised in air-launched cruise missiles (and target drone versions of these) from its birth. In 1967 it broke away from the Mikoyan OKB and was known henceforth as GMKB ***Ra**duga* ('Rainbow' State Machinery Design Bureau).



Above: This radio-controlled helicopter developed jointly by GMKB Raduga and the Moscow Aviation Institute as a civil surveillance platform was displayed at the MAKS-2003.



Another offering from the same design tandem, this remote-controlled aircraft was developed specifically for forestry patrol duties.

Two unnamed compact UAVs developed by GMKB Raduga jointly with the Moscow Aviation Institute (MAI) were demonstrated at the MAKS-2003 airshow. Both were designed for civil purposes, such as ecological monitoring and pipeline/power line monitoring.

The first model is a helicopter utilising the classic layout with two-bladed main and tail rotors, a skid landing gear and a two-cylinder engine mounted aft of the main gearbox. The helicopter has a 32-kg (70.5-lb) take-off weight and can carry an 18-kg (39-lb) payload over a range of 20 km (12.4 miles). Length with rotors turning is 1.8 m (5 ft 10$^{55}/_{64}$ in), with a main rotor diameter of 0.55 m (1 ft 9$^{21}/_{32}$ in), and the helicopter stands 0.24 m (9$^{29}/_{64}$ in) tall on the ground.

The other one is an aircraft with cantilever shoulder-mounted wings using a thick airfoil, a conventional tail unit with low-set stabilisers, a fixed tricycle landing gear and a horizontally opposed two-cylinder engine driving a two-bladed tractor propeller. This UAV is specifically developed for the forestry patrol mission. It is 1.56 m (5 ft 1$^{13}/_{32}$ in) long and 0.45 m (1 ft 5$^{23}/_{32}$ in) high, with a wing span of 2.8 m (9 ft 2$^{15}/_{64}$ in); the take-off weight is 25 kg (55 lb), including a 10-kg (22-lb) payload, and the aircraft has a 100-km (62-mile) range.

Basic specifications of the SKB Topaz mini-drone

Cruising speed, km/h (mph)	60-120 (37-74.5)
Maximum flight altitude above sea level, m (ft)	3,000 (9, 480)
Maximum flight altitude above ground level, m (ft)	100-600 (330-1,970)
Operational radius, km (miles)	20 (12.4)
Maximum endurance	1 hour
Take-off weight, kg (lb)	3 (6.6)
Mission equipment	TV/IR imaging equipment
Error margin on the route	no more than 50 m (164 ft)

The SKB Topaz company's mini-drone (minus mission equipment) at the MAKS-2003. Note the negative wing sweep, the linked stabilators, the twin vertical tails and the folded propeller blades.

Kamov is not the only Russian manufacturer of helicopters with contra-rotating rotors. This is the Yula-1 designed by the Samara State Aerospace University for just-where-you-need-it agricultural work.

SKB Topaz mini-drone

At the MAKS-2003 the Moscow-based SKB Topaz design bureau presented a mini-UAV intended for remote geophysical/ecological survey. It is a small aircraft with gently forward-swept wings and twin tails powered by a single-cylinder engine with a folding tractor propeller. The drone is launched by hand and follows a pre-programmed course, gliding to earth at the end of the mission. The system includes a mission preparation/data processing module based on a laptop computer.

Other fixed-wing UAVs

Information disseminated at the MAKS-2003 contained reference to a pilotless electronic countermeasures (ECM) platform designed for jamming UHF communications; developed as a joint Russian/Belorussian effort, it was a follow-on to the existing *Moshkara* (Swarm of midgets) ECM system.

Mention was also made of the *Otshel'nik* (Hermit) reconnaissance UAV developed by *Novik – Dvadtsat' pervyy vek* in partnership with Ukrainian companies.

SGAU Yula-1 pilotless helicopter

The static park at the MAKS-2003 featured a pilotless mini-helicopter designed for ultra-low-capacity crop spraying work. Developed by the Samara State Aerospace University (SGAU – *Samarskiy gosoodarstvennyy aerokosmicheskiy ooniversitet*), the machine was dubbed *Yula-1* (Spinning top-1). The name was an apt one: the very compact helicopter featuring three-bladed contra-rotating rotors and a four-strut landing gear indeed resembled a top because of its squashed quasi-spherical body serving as the chemical tank.

GUAP/Radar-MMS pilotless helicopter

At the International Maritime Defence Show-2003 held in St. Petersburg between 28th and 30th June 2003 the Radar-MMS avionics house displayed a pilotless heliborne surveillance system. This was nothing more than a stock radio-controlled model helicopter of Western origin fitted with a TV camera. Curiously, it bore a logo reading GUAP (in Russian); this acronym had been used of old for the Chief Directorate of Aircraft

Industry (***Glahv**noye oopravl**eni**ye aviatsi**on**noy pro**mysh**lennosti*), a precursor of MAP, but the current meaning is unknown

GUAP/Severnyy Press pilotless helicopter

Another interesting exhibit of IMDS-2003 was a pilotless heliborne surveillance system developed by the local ***Sev**ernyy Press* (Northern Press) company; in this case, 'press' means a piece of hydraulic machinery, not the media. The helicopter had two-bladed contra-rotating rotors and a twin-fin tail unit; it also bore the GUAP logo. Unfortunately no further details were available

Pustel'ga rotary-wing micro-UAV

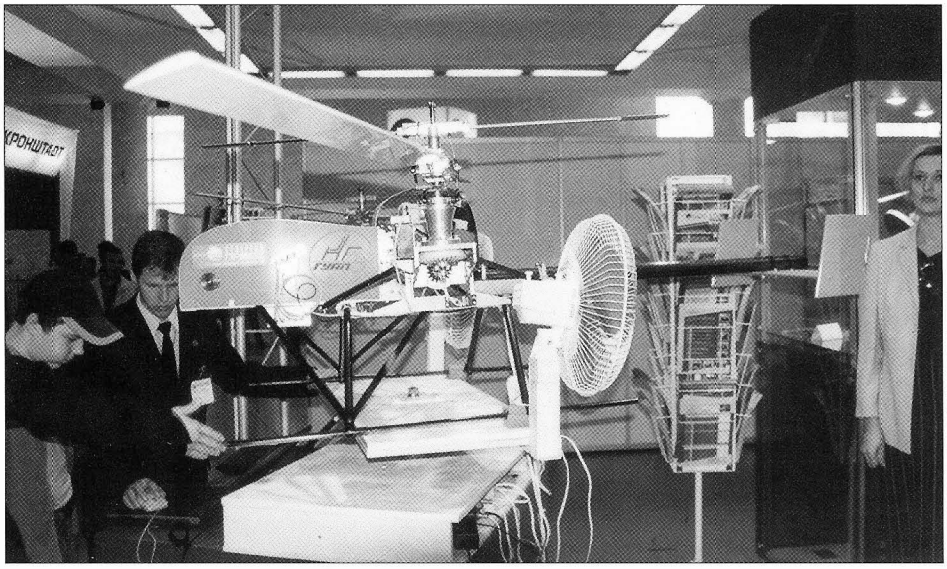
A completely new class of aerial vehicles appeared and started developing rapidly at the turn of the century – miniature UAVs literally small enough to land on the palm of your hand, with an all-up weight of a few hundred or even a few dozen grams. In Russia, the V. I. Kuznetsov Applied Mechanics Research Institute is making the greatest headway in this field. It is this establishment that is responsible for the *Pustel'**ga*** (Kestrel) reconnaissance UAV weighing just 300 grams.

This miniature helicopter (hence the 'hoverbird' name) has a number of hitherto unseen features that place it in a class of its own. The UAV, which is operated by one person (all the required control and support equipment is compact enough to fit into a briefcase), incorporates all the latest state-of-the-art in micromechanics and micro-systems technology, including microsensors and an integrated platform-less inertial control system.

The Pustel'ga is manufactured entirely of composites, which accounts for its extremely small RCS. The four rotors are driven by miniature electric motors, rendering the UAV's flight virtually silent. When the Pustel'ga is more than 50 m (164 ft) away it cannot be seen with the naked eye, even if you have 20/20 vision; the helicopter's high agility and stealth enables it to literally fly into enemy-held buildings and bunkers to explore them from within. Apart from the baseline reconnaissance version equipped with a stabilised miniature TV camera, the V. I. Kuznetsov Applied Mechanics Research Institute has developed a strike version capable of delivering a miniature charge exactly to the spot where it will do the greatest damage.

If the Pustel'ga enters quantity production, its price tag will be around US$ 10,000; this should make it possible to introduce adequate numbers of micro-UAVs right down to battalion, company and squad level without incurring unacceptably high costs. The reconnaissance version would be a valuable asset during combat in mountainous, inaccessible or swampy areas or when crossing rivers, while the strike version would be a highly effective weapon during anti-terrorist or special forces/law enforcement operations.

Above: This helicopter displayed at the IMDS-2003 show is a stock Western-made RC model. However, it is fitted with a TV surveillance system developed by Radar-MMS and bears an obscure GUAP logo.



This strange-looking radio-controlled surveillance chopper shown at IMDS-2003, in contrast, is obviously too crude to be a Western model. It carries the same GUAP logo and a Severnyy Press logo.

Berkoot unmanned aerostatic stratospheric surveillance platform (project)

Another interesting and promising area of aviation engineering which has been receiving attention in Russia lately is airships – and tethered aerostats. One of the notable 'airship-builders' in Russia is the Moscow-based Avgur Aeronautical Centre which is working on a unique airborne surveillance platform called ***Ber**koot* (Golden Eagle) based on an airship. Actually surveillance aerostats equipped with radars are nothing new; in the USA, three companies (ILC Dover, RCA Service Co. and TCOM Corporation) have 'been there and done that'. However, Avgur's project is an airship, not an aerostat. Moreover,

Basic specifications of the Berkoot airship

Configuration	ET	ML	HL
Volume, m^3 (cu ft)	192,000 (6,780,422)	256,000 (9,040,563)	320,000 (11,300,704)
Length overall	150 m (492 ft 1½ in)	200 m (656 ft 2 in)	250 m (820 ft 2½ in)
Maximum diameter	50 m (164 ft 0½ in)	50 m (164 ft 0½ in)	50 m (164 ft 0½ in)
Maximum take-off weight, kg (lb)	13,500 (29,760)	18,000 (39,680)	22,500 (49,600)
Payload, kg (lb)	1,200 (2,645)	1,200 (2,645)	1,200 (2,645)
Solar battery area, m^2 (sq ft)	3,500 (37,934)	5,800 (62,365)	8,000 (86,021)
Endurance, months	4	4	1

The ENICS Research Centre's pulse-jet powered target drones include the E95; this example (c/n 39) is depicted at the MAKS-2003 airshow.

what makes it unique is that it is designed for stratospheric altitudes; in contrast, the American aerostats operated at altitudes around 3,000 m (9,800 ft).

The Berkoot unmanned airship is able to maintain a constant position at an altitude of 20,000-23,000 m (65,620-75,460 ft) for an extended period. It carries up to 1,200 kg (2,645 lb) of mission equipment, electric power for it being supplied by solar cell panels attached to the airship's envelope. The geostationary position of the airship enables it to survey (or perform communications/relay functions over) a territory in excess of 1 million square kilometres (386,100 sq miles), which is comparable to the area of France.

Unlike surveillance or communications satellites, which are non-recoverable and hence extremely costly, the Berkoot is able to land every three or four months for scheduled maintenance, repairs or changes to the mission equipment fit.

Three basic versions of the Berkoot airship are envisaged; these are designated ET (Equator & Tropics, that is, up to 30°N/30°S), ML (Medium Latitudes, that is, 30-45°) and HL (High Latitudes, that is, 45-60°) to indicate where the airship is to operate. All three share the same structural and systems components, differing mainly in the area of the solar cell panels, which affects the size of the envelope; the greatest number of solar cells and storage batteries is required in high latitudes. Also, due to the lower wind speeds near the equator the electric power required for the platform's operation (including station keeping) is about 30% less than in high latitudes.

All three versions have the same type of fin/rudder assemblies which also mount electric motors driving propellers of 6.0 m (19 ft 8⁷⁄₃₂ in) diameter. The number of fins, however, is different; the Berkoot HL has seven, the Berkoot ML has five and the Berkoot ET just three. A key element of the airship's design is the power transformation system which makes use of the latest Russian space technology.

The Berkoot will be able to maintain detailed and virtually uninterrupted surveillance of areas of interest, which is of special importance during anti-terrorist operations and limited armed conflicts. A high-altitude aerostatic platform offers the possibilities of transferring data rapidly to mobile user terminals and creating a new data transfer/processing system infrastructure.

A special inflatable shed (that is, hangar) has been developed for the Berkoot airship; this modular structure can be erected anywhere within 15 hours. Depending on the number of modules, the shed may be 180 m (590.55 ft), 210 m (688 ft 11 in) or 270 m (885 ft 10 in) long.

Basic specifications of the ENICS target drones

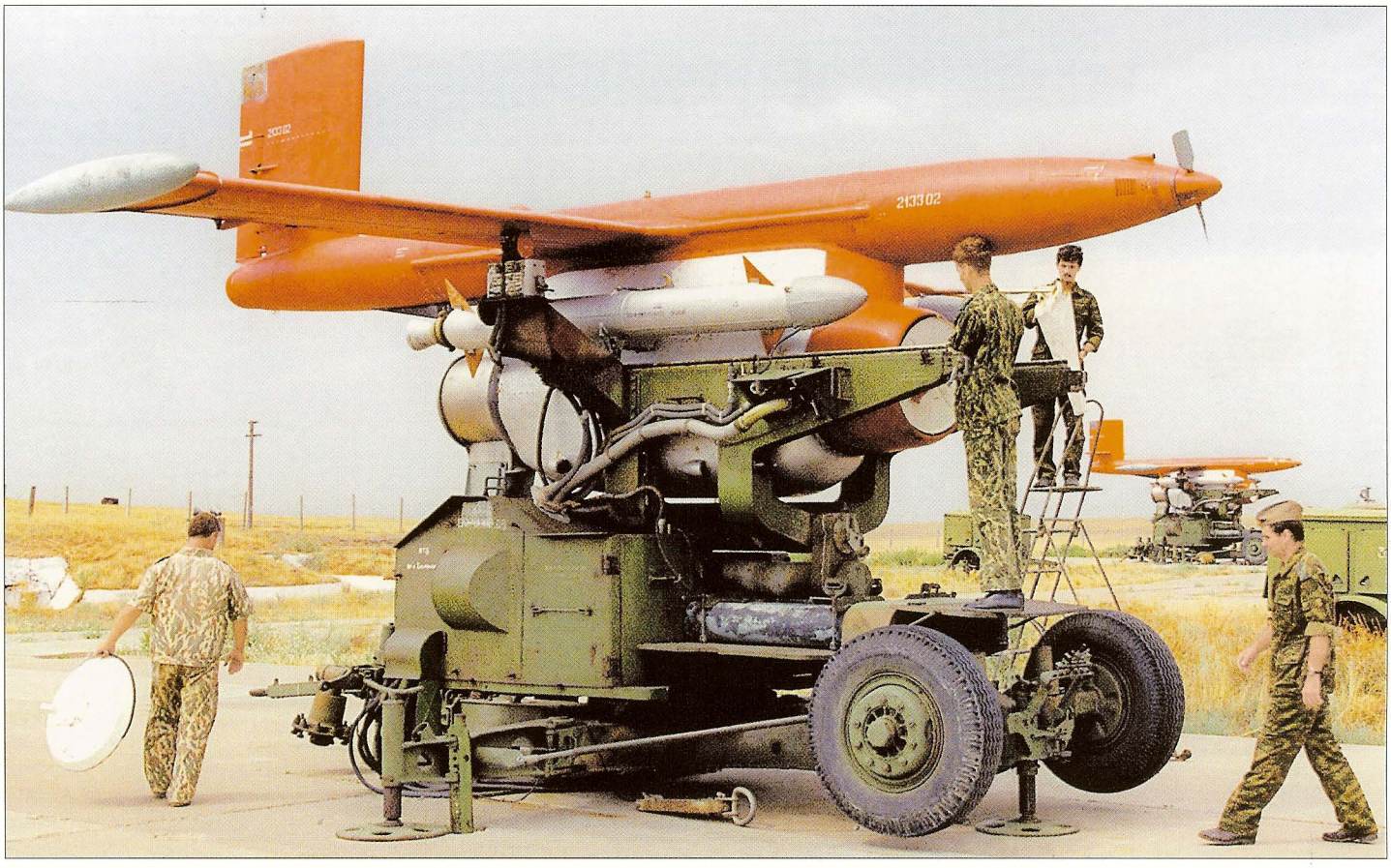
	E85	E95
Length overall	3.2 m (10 ft 5⁹⁄₆₄ in)	2.1 m (6 ft 10⁴⁵⁄₆₄ in)
Wing span	2.0 m (6 ft 6¾ in)	2.4 m (7 ft 10³¹⁄₆₄ in)
Height on ground	0.84 m (2 ft 9 in)	0.55 m (1 ft 9²¹⁄₃₂ in)
Launch weight, kg (lb)	120 (265)	60 (132)
Range, km (miles)	70 (43.5)	70 (43.5)
Speed, km/h (mph)	250-600 (155-372)	380-410 (236-254)
Endurance, minutes	n.a.	22-40
Flight altitude above ground level, m (ft)	200-3,000 (660-9,840)	200-3,000 (660-9,840)
Launch	Heliborne	Ground
Recovery	Parachute	Parachute
Service life, cycles	n.a.	10
Control crew	4	5

ENICS E85 target drone

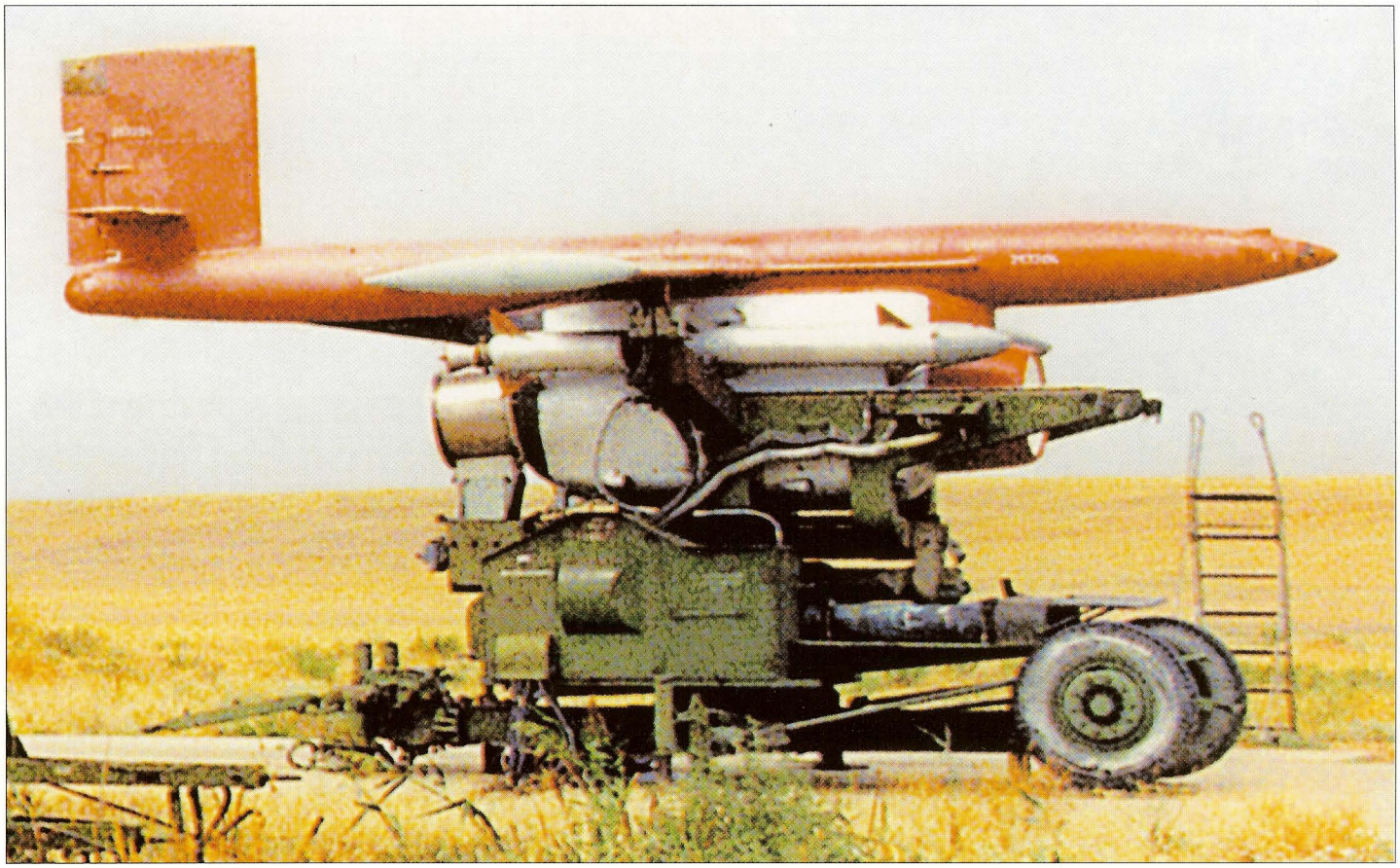
At the MAKS-95 airshow the ENICS Research Centre displayed the E85 target drone intended for emulating cruise missiles and even guided bombs. Powered by a 40-kgp (88-lbst) pulse-jet engine buried in the fuselage, the E85 has a conventional low-wing layout with an oval-section fuselage. The drone has an RCS of 0.1-1.0 m² (1.07-10.75 sq ft).

ENICS E95 target drone

Another product of the ENICS Research Centre is the E95 target drone intended for the same purposes. It is powered by the same pulse-jet, but here the engine is mounted above the circular-section fuselage and the tail unit features twin fins and rudders.



Above: A La-17MM (La-17K) target drone (c/n 213302) on a launcher, with a second example visible beyond. The target drone versions were typically red overall; the white-painted engine cowling of this one is characteristically bulged to accommodate the accessory gearbox of the R11K engine.



Another La-17K (c/n 213304) at the launch pad. Judging by the concrete pavement, this was a full-time installation at a PVO weapons training range.

Above: This La-17MM (La-17K) target drone (c/n 213628) on a ground handling dolly is preserved at the GNIKI VVS Museum at Vladimirovka AB in Akhtoobinsk.

A CK-1B drone serialled '2037 Black' with equipment pods under the wings. The shape of the wingtip pods and the absence of the nose generator drive vane are clearly visible, as is the totally different design of the Chinese ground handling dolly.

Above: A CK-1A ('8305 Black') shows off its underwing fuel tanks and small cylindrical wingtip pods.

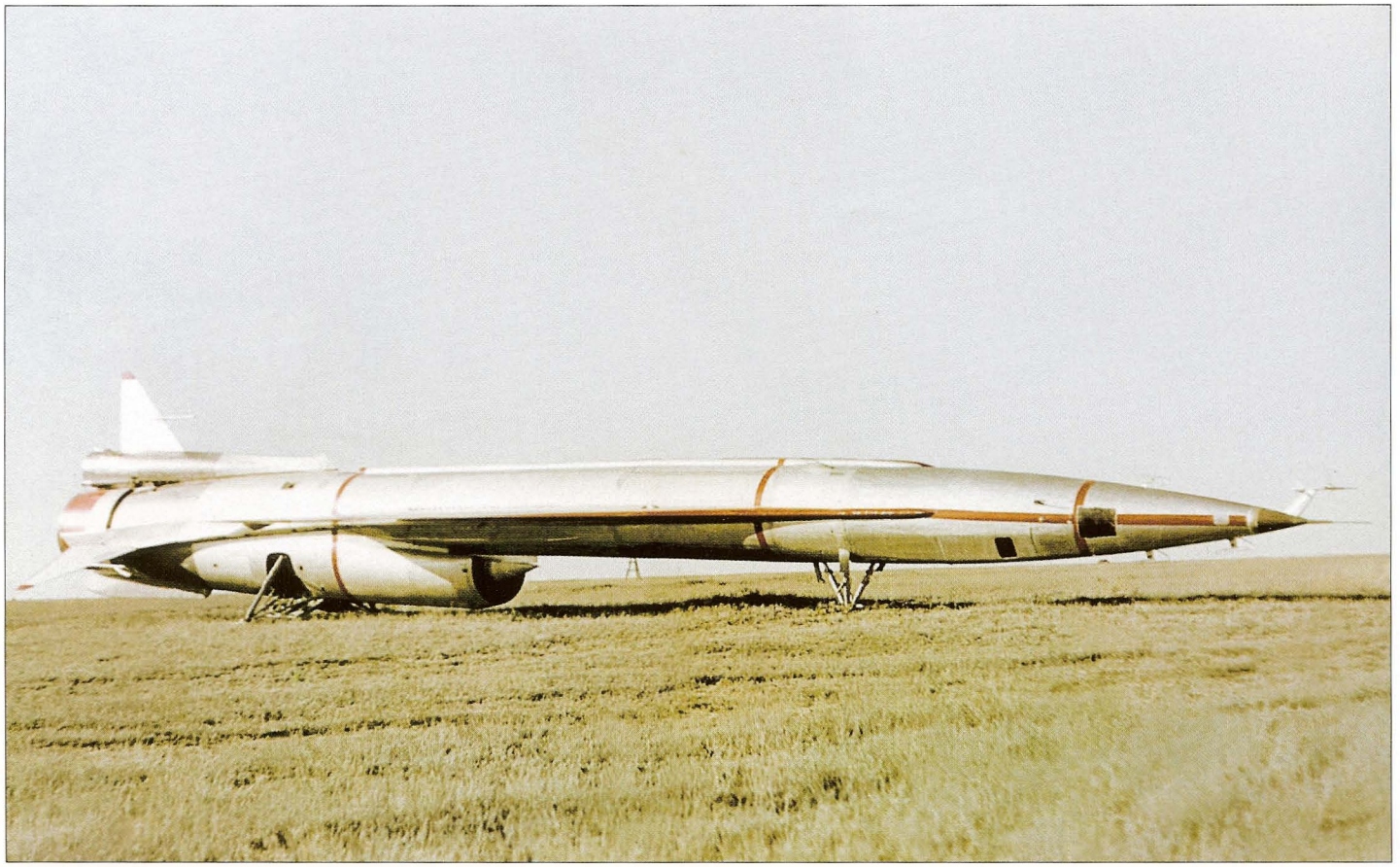
Another CK-1A, '8704 Black', with a mobile tester connected. The significance of the Roman letters painted all over the fuselage (AAABBBCCCDDDEEEFFFGGG and so on) is not known.

Above: This La-17RM reconnaissance drone (c/n 50115) was preserved in the open at Moscow-Khodynka, with a resulting deterioration in its condition. The nose-up attitude is probably a result of unruly kids clambering on top of the thing and upsetting the balance.

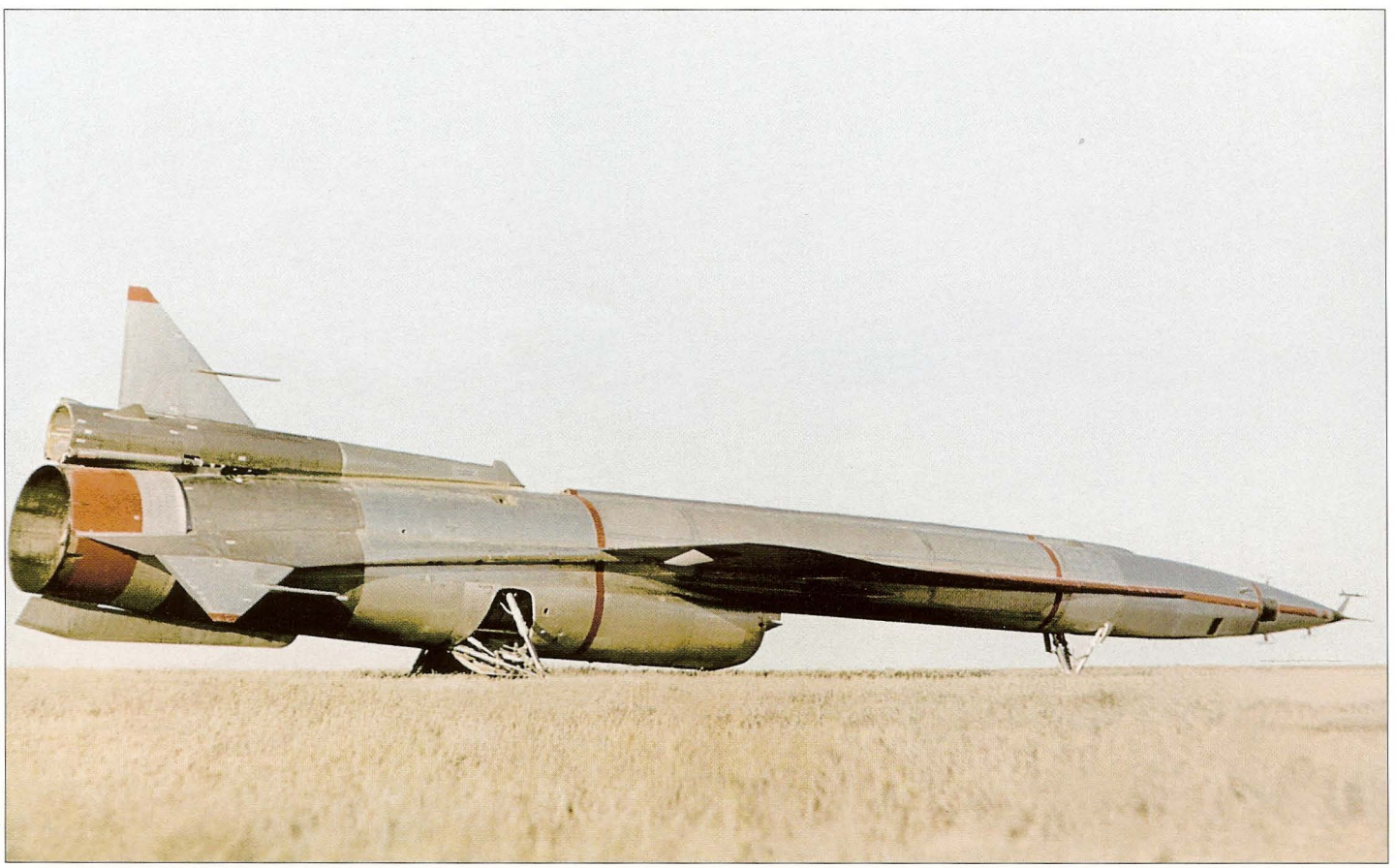
An SARD-1 (STA-30) transporter/launcher vehicle with a fully assembled '123' (Tu-123) reconnaissance drone rolls along a dirt road, heading towards the chosen launch pad.

Above: The same TLV at the launch pad, with the hydraulic supports in place, the ramp of the SURD-1 (ST-30) semitrailer elevated and the MAZ-537V tractor unit disengaged and ready to drive away to safety.

Another view of the Tu-123 positioned at the launch pad, showing the red markings typical of development examples. Note that the nozzle's ejector ring is painted red overall.



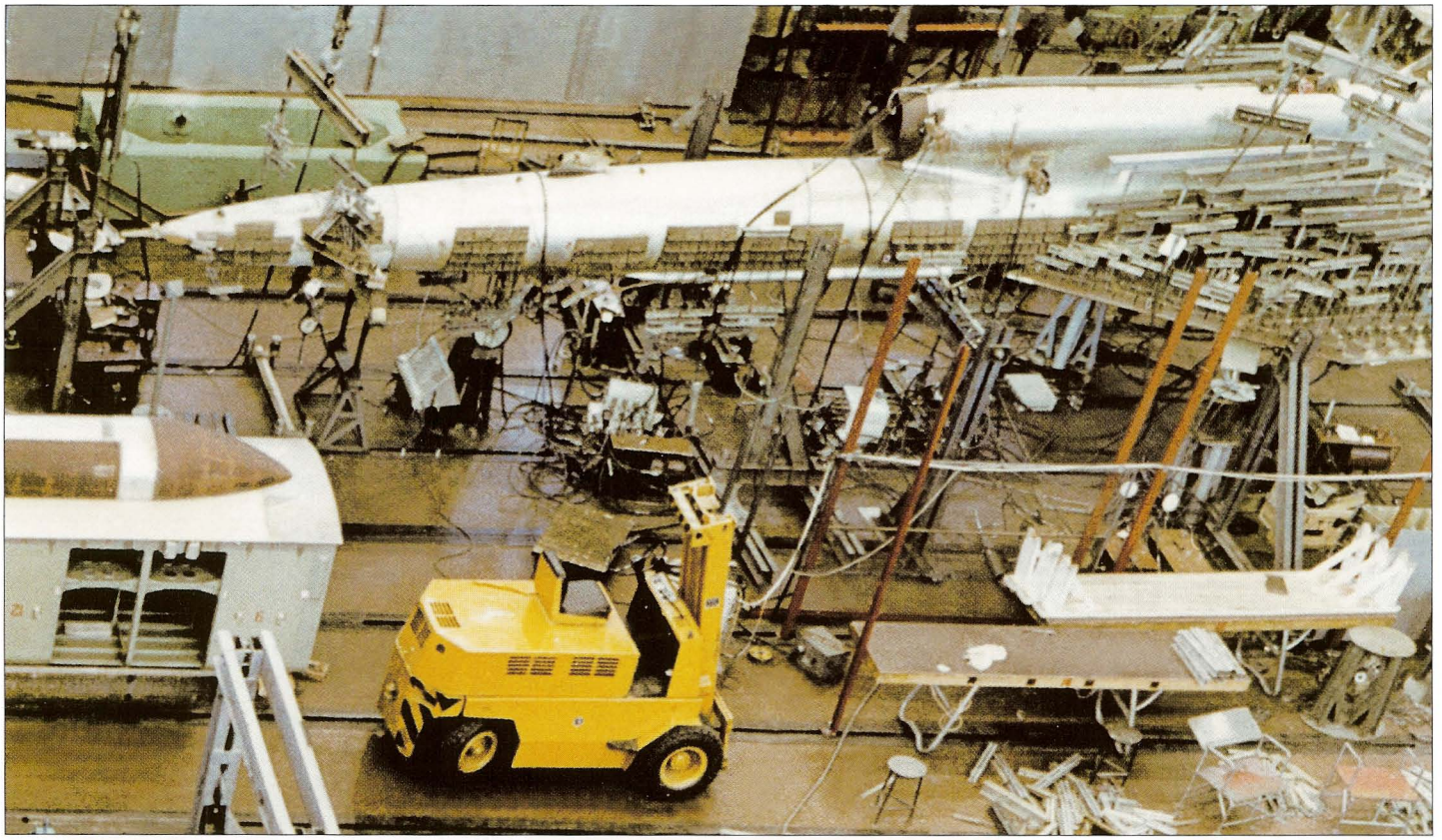
Above: The '139' (Tu-139) was a fully reusable version of the Tu-123. This photo of the prototype shows clearly the retractable tricycle landing gear. Note the dielectric panel on the side of the nose ahead of the oblique camera port covering the SRS-4 ELINT system antennas.



Another view of the Tu-139 after a test flight; the brake parachute container cover above the nozzle and the dorsal recovery parachute container cover amidships are gone. Note the anti-flutter booms on all control surfaces.

Above: The Tu-139 on an SARD-1 TLV (featuring the other version of the semitrailer this time). This view shows clearly the ogival wings, the telemetry aerials on the nose and the L-shaped air data system probe at the tip of the nosecone.

A Ukrainian Air Force Tu-141 reconnaissance drone coded '15 Red' takes off during an exercise, the rocket booster roaring full blast. Two of the watching servicemen are equipped with protective earphones; the third one (on the left) got none and has no choice but to plug the ears.

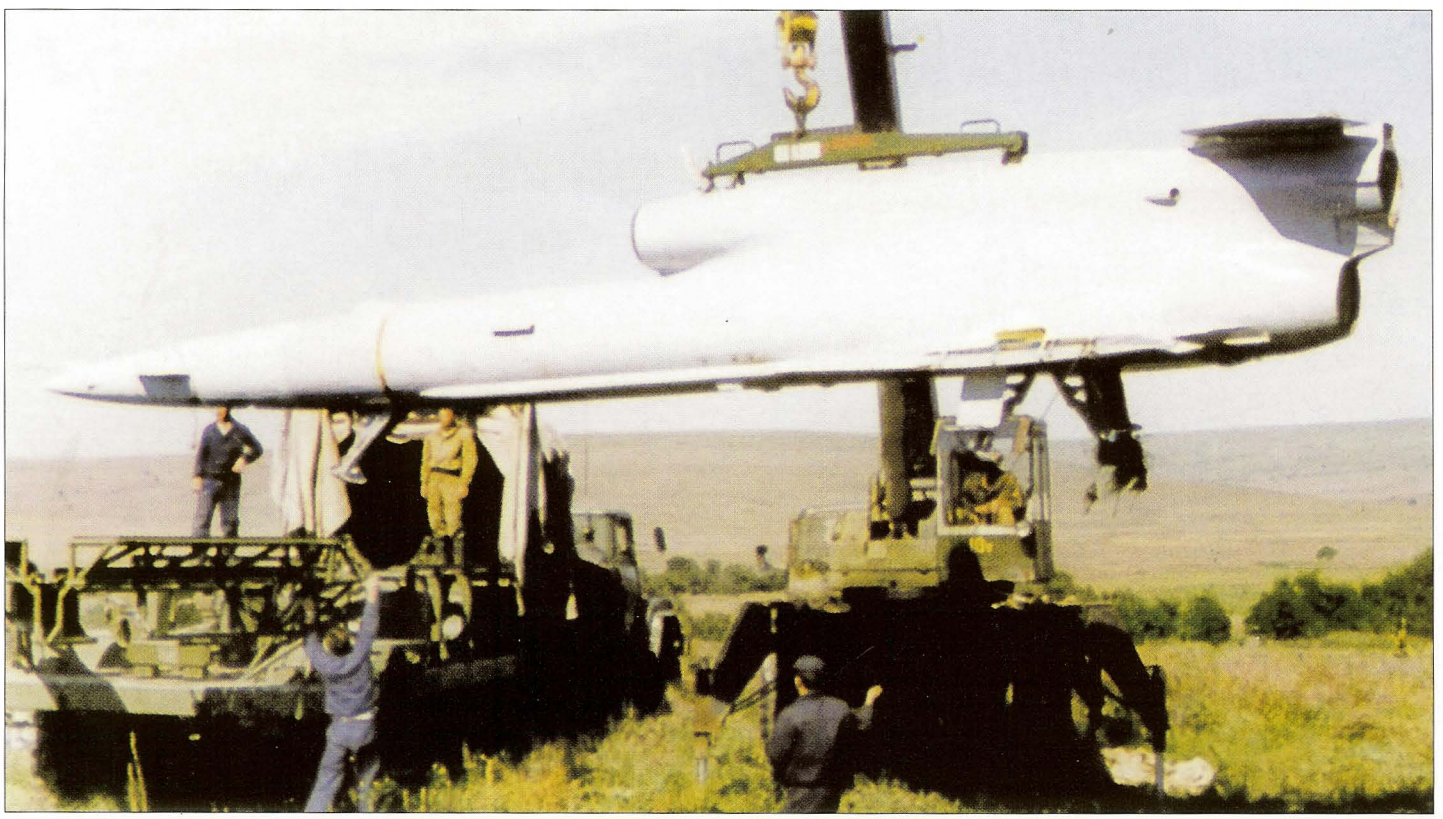


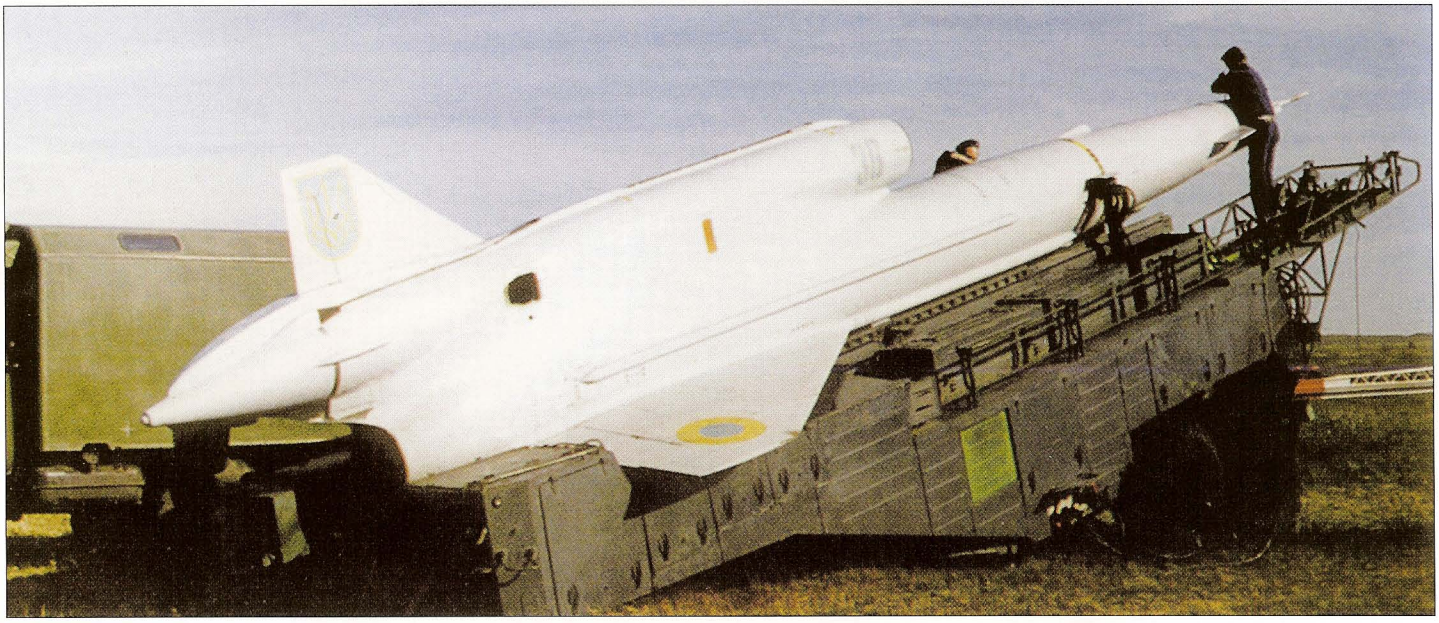
Above: A Tu-141 undergoing static tests. A section of airframe obviously pertaining to a different aircraft is visible on the left.

Below: Wings and fin folded to save space and a cargo handling bar attached, an ogival-nose Tu-141 is lifted by a mobile crane with a 10-ton (22,045 lb) capacity on an Ural-43212 chassis and placed on a TZM-141 recovery vehicle (a KrAZ-260V with a special semitrailer). The brake parachute fairing is gone.

Top right: A UPG-300 ground power unit on a ZiL-131N chassis (still with an old Soviet military number plate, 86-11 ZhE) powers up an SPU-141 launcher with Ukrainian Air Force Tu-141 '18 Blue' during an exercise. Note the scorched blast shield on the launcher and the bundle of camouflage on the GPU's cab roof.

Right and below right: Another Tu-141 in current Ukrainian Air Force markings ('36 Blue') before launch and at the moment of launch.





Ту-141

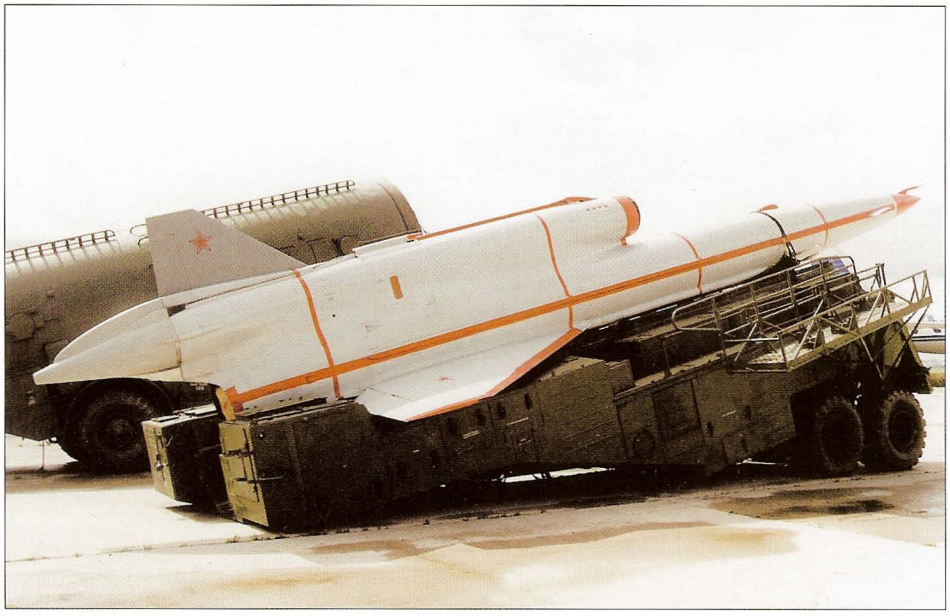
Left: A late-model ogival-nosed Tu-141 on an SPU-141 launcher in the static park of the MAKS-97 airshow at Zhukovskiy. The same example was displayed there two years earlier minus launcher. Note the V shape of the camera port glazing.

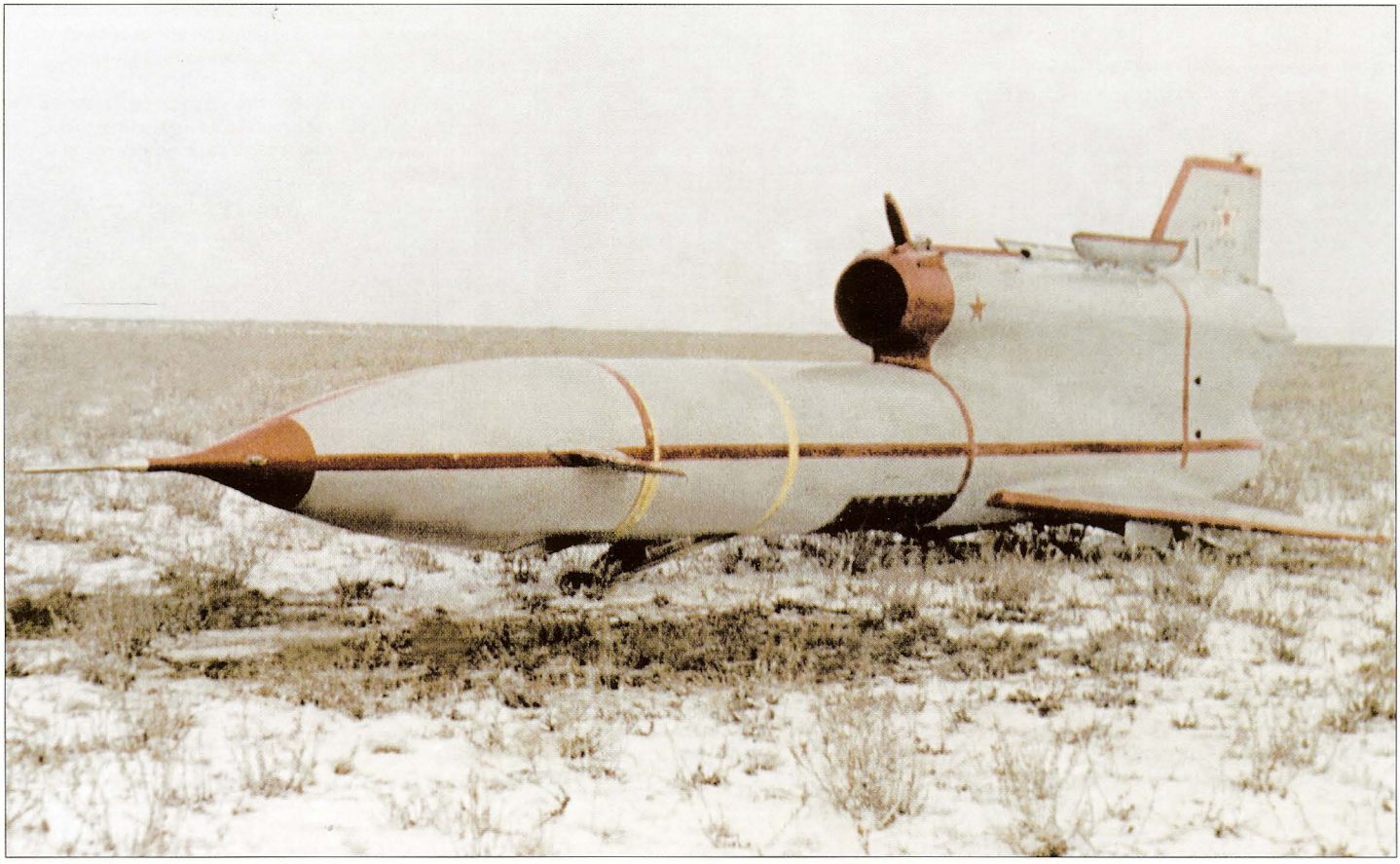
Below left: Three-quarters rear view of the same aircraft. The GRP tailcone differs in colour from the metal fuselage.

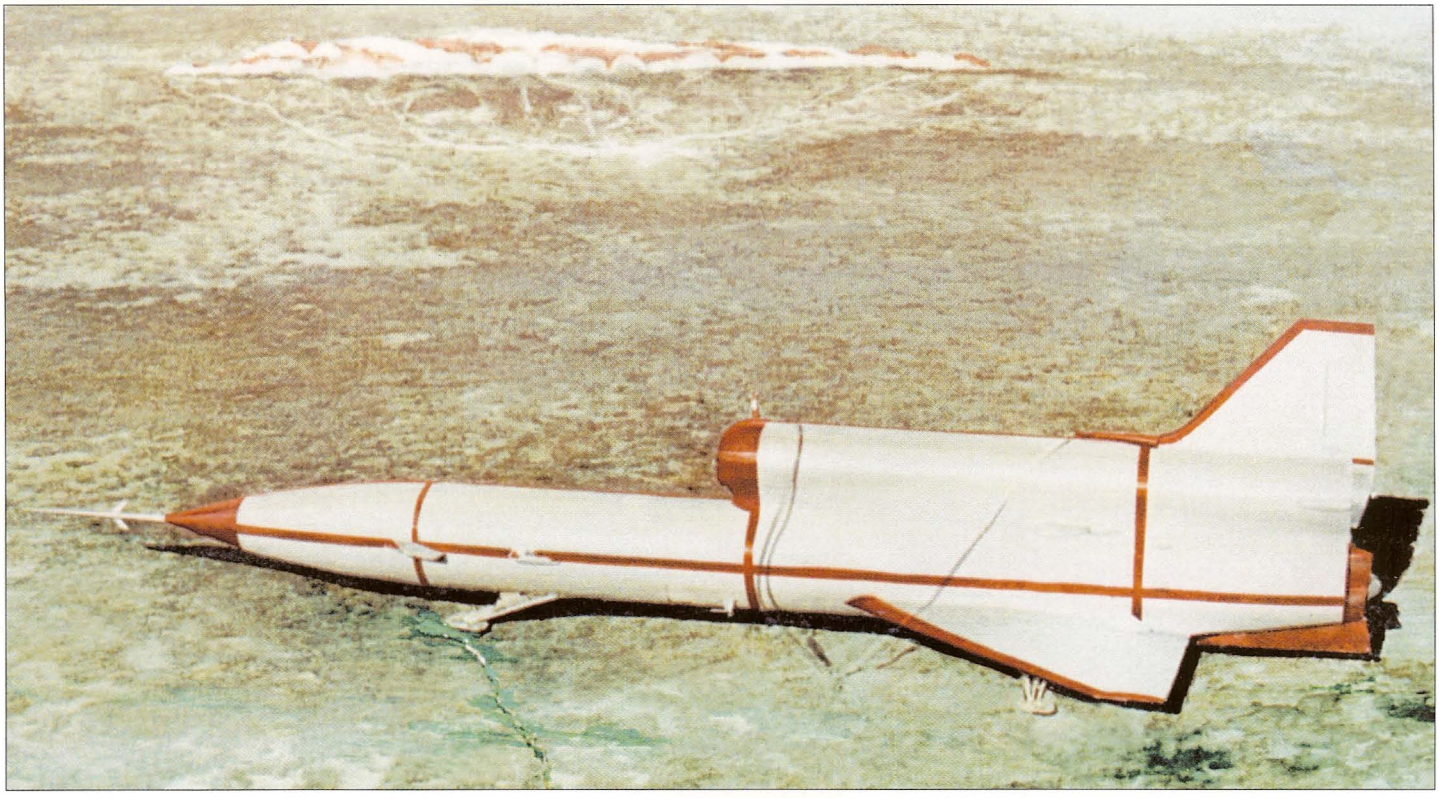
Right: Another aspect of the Tu-141 at the MAKS-97.

Below: This Tu-141 mounted on a plinth with the landing gear up is preserved at its birthplace, the Khar'kov State Aircraft Manufacturing Co., at Khar'kov-Sokol'nikovo. The drone sports four stars to mark missions flown. Other exhibits include a UTI-MiG-15 advanced trainer and a Yak-18A basic trainer visible here; both were likewise produced in Khar'kov.

Bottom: In contrast, Tu-141 '05 Yellow' at the Central Russian Air Force Museum in Monino has the landing gear deployed, which does not tie in with the present brake parachute fairing.







Left: Big brother and little brother. The Tu-141 makes an interesting comparison with the smaller Tu-143 sharing the same general arrangement

Top: A Tu-143 sits in the field where it has landed. Note how the snow in front of the drone has been blown away by the retro-rocket. The star on the air intake trunk complementing the usual one on the tail is also noteworthy.

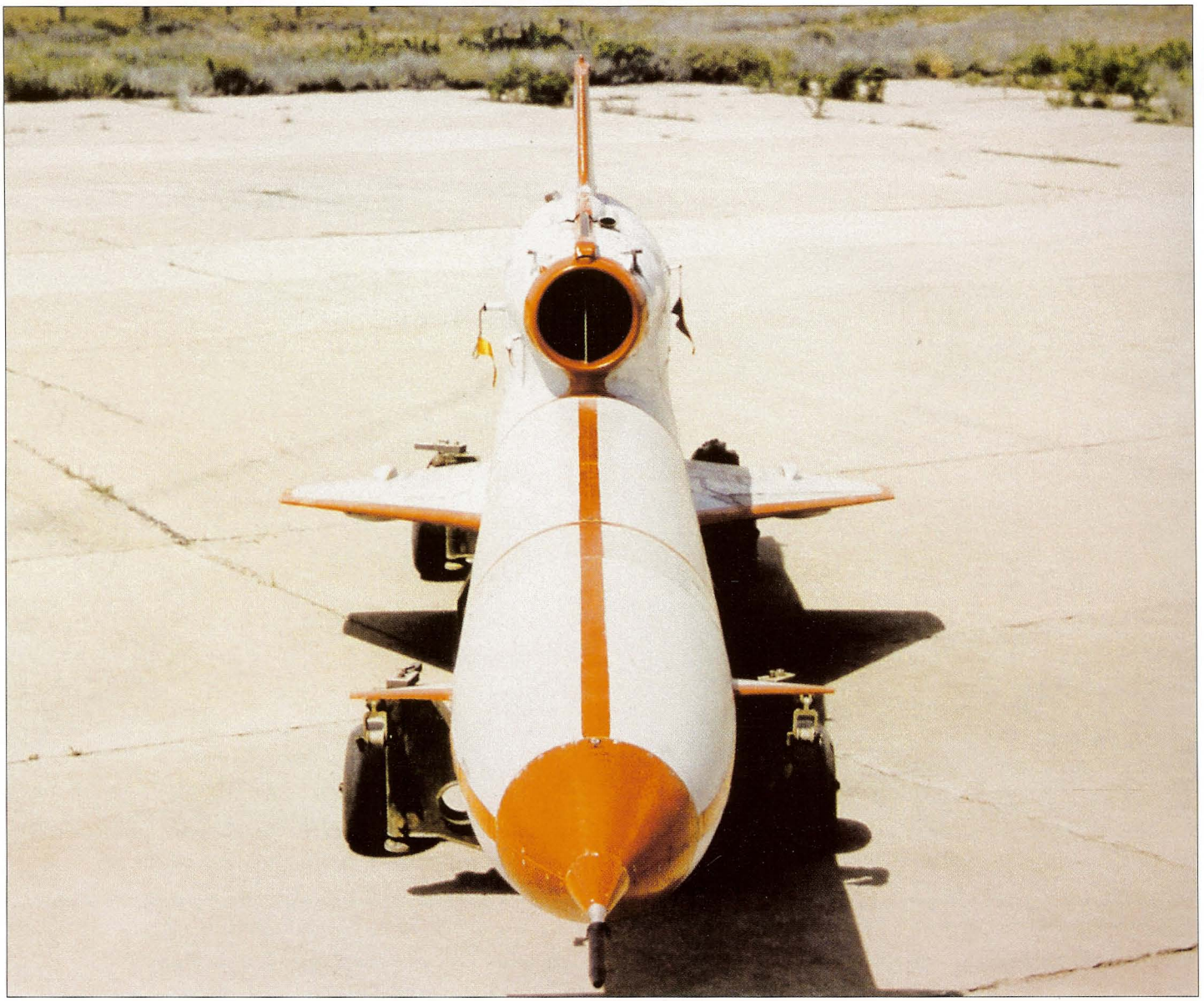
Above: This Tu-143 photographed after landing features a non-standard tall fin/rudder assembly and a ventral strake under the engine jetpipe.

Left: Rear view of a Tu-143 on a ground handling dolly. Note the wing anhedral and the elevon actuator fairings at approximately half-span.

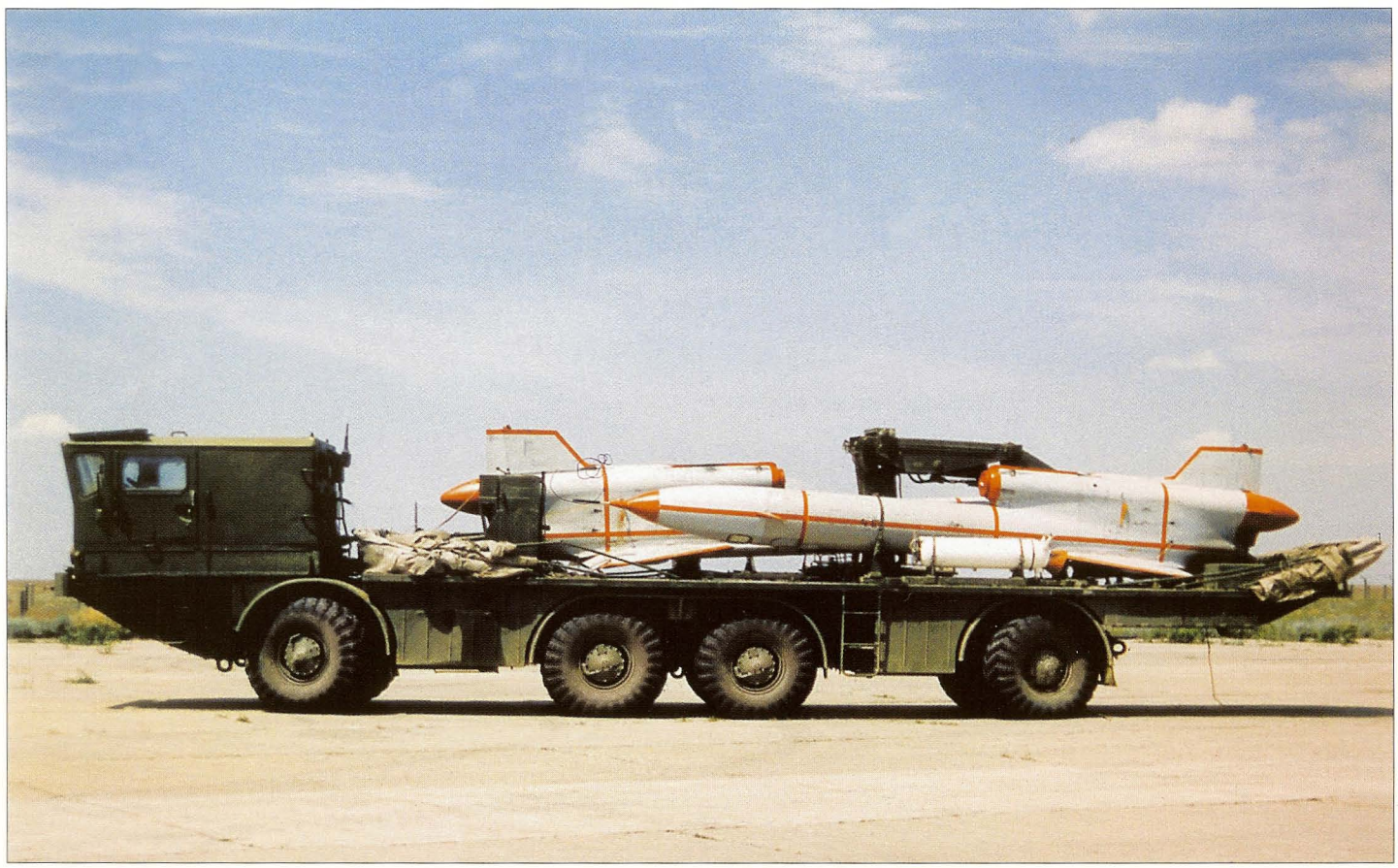
Below: Front view of the same drone. Note how the fuselage bulges aft of the air intake to provide room for the fuel and the parachute recovery system.

Right: Three-quarters front view of a Tu-143 in photo reconnaissance configuration with two cameras in tandem. The Tu-143 is a compact vehicle. The production version had a somewhat puffier nose than the prototypes shown on the preceding pages.

Below right: A side view of the same drone. Most examples of the Tu-143 had a cropped vertical tail due to the need to fit into the limited space of the launch tube.



Above: An SPU-143 self-propelled launcher on a BAZ-135MB eight-wheel drive, four-wheel steering chassis (number plate 70-02 KhKh, in Cyrillic letters).The aft end of a Tu-143 can be seen through the open rear cover which incorporates an inspection hatch.



The TZM-143 transporter/loader vehicle on the same chassis can carry two Tu-143s facing in opposite directions (shown here in pre-launch condition); the SPRD-251 rocket boosters are secured alongside. Note how the wheels of the steerable front and rear axles turn in the opposite directions.

Above: A three-quarters view of the SPU-143. The early version of the SP launcher designed for working with the Tu-143 is identifiable by the dished front and rear covers of the launch tube. This example is in standard overall olive drab finish.

The SPU-143 in travel configuration with the tube level and the covers closed. The steps/hand holds on the side of the tube serve for climbing on top in order to cover the vehicle with camouflage netting.

Above: This Tu-143 preserved at the GK NII VVS Museum in Akhtoobinsk features non-standard lock fairings at the nose section/forward fuselage joint and yellow bands around the fuselage to complement the usual red markings.

A Ukrainian Air Force TZM-143 (note the St. Volodymir trident on the cab door) uses its hydraulic crane to load a Tu-143 sporting full UAF insignia, the code '61 Red' and the same yellow bands into an SPU-143. Note the ramp extended from the rear of the launch tube to assist loading. A second Tu-143 is still under wraps.

Above: Ukrainian Air Force TZM-143 '05 Red' lets loose a Tu-143 coded '43 Red'. The flame of the booster appears certain to do at least some damage to the chassis.

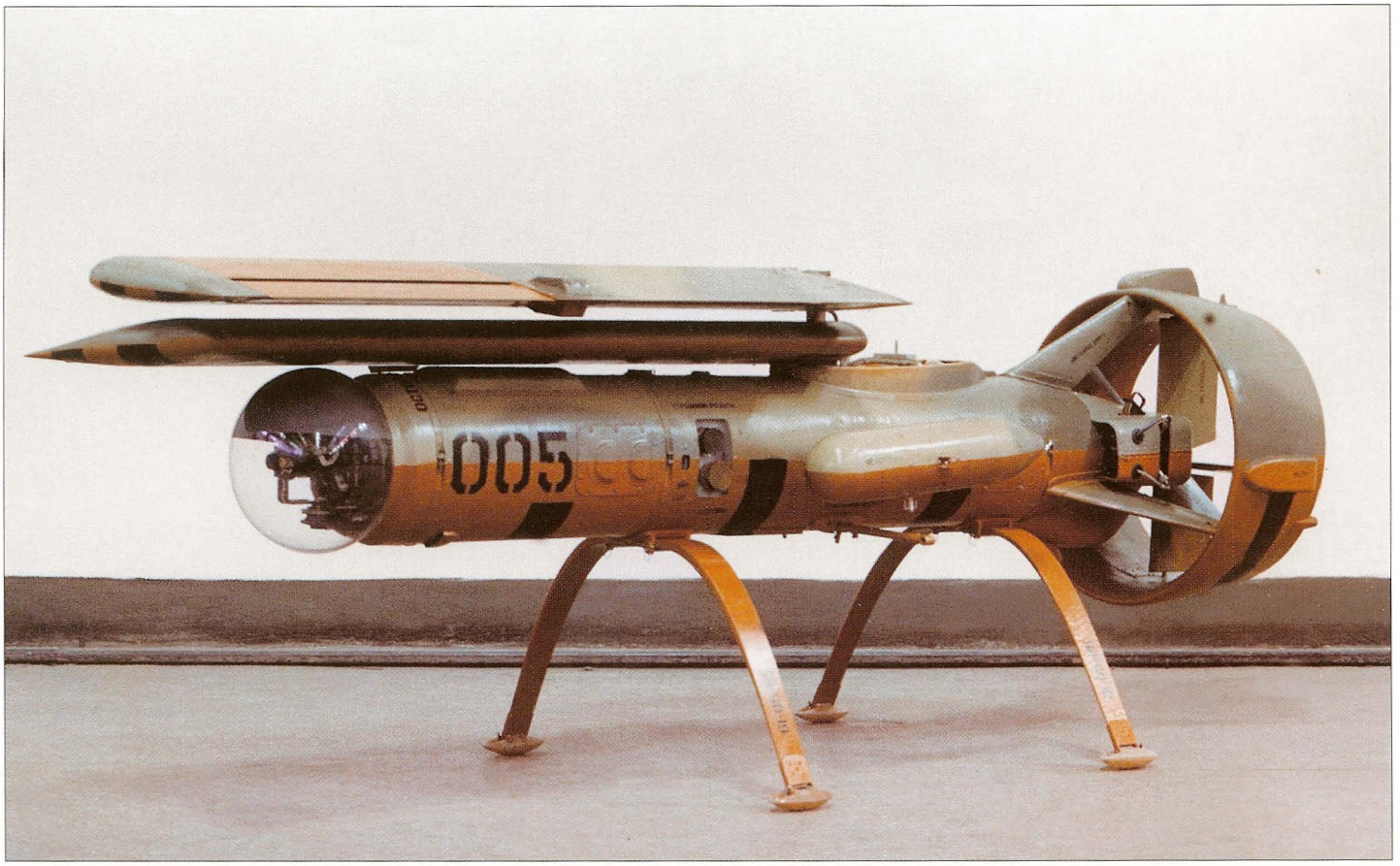
A Tu-243 on display at the MAKS-97, with a second example in the launch tube of the SPU-243 alongside. The BAZ-135MB is not the easiest of vehicles to climb into, and the personnel at the show have chosen to use a special ladder rather than the standard steps, as shown here.

Above: Outwardly the SPU-243 (shown here in travel configuration) can be discerned from its forerunner, the SPU-143, by the launch tube covers which have a cropped conical shape instead of being dished; accordingly there are no more inspection hatches.

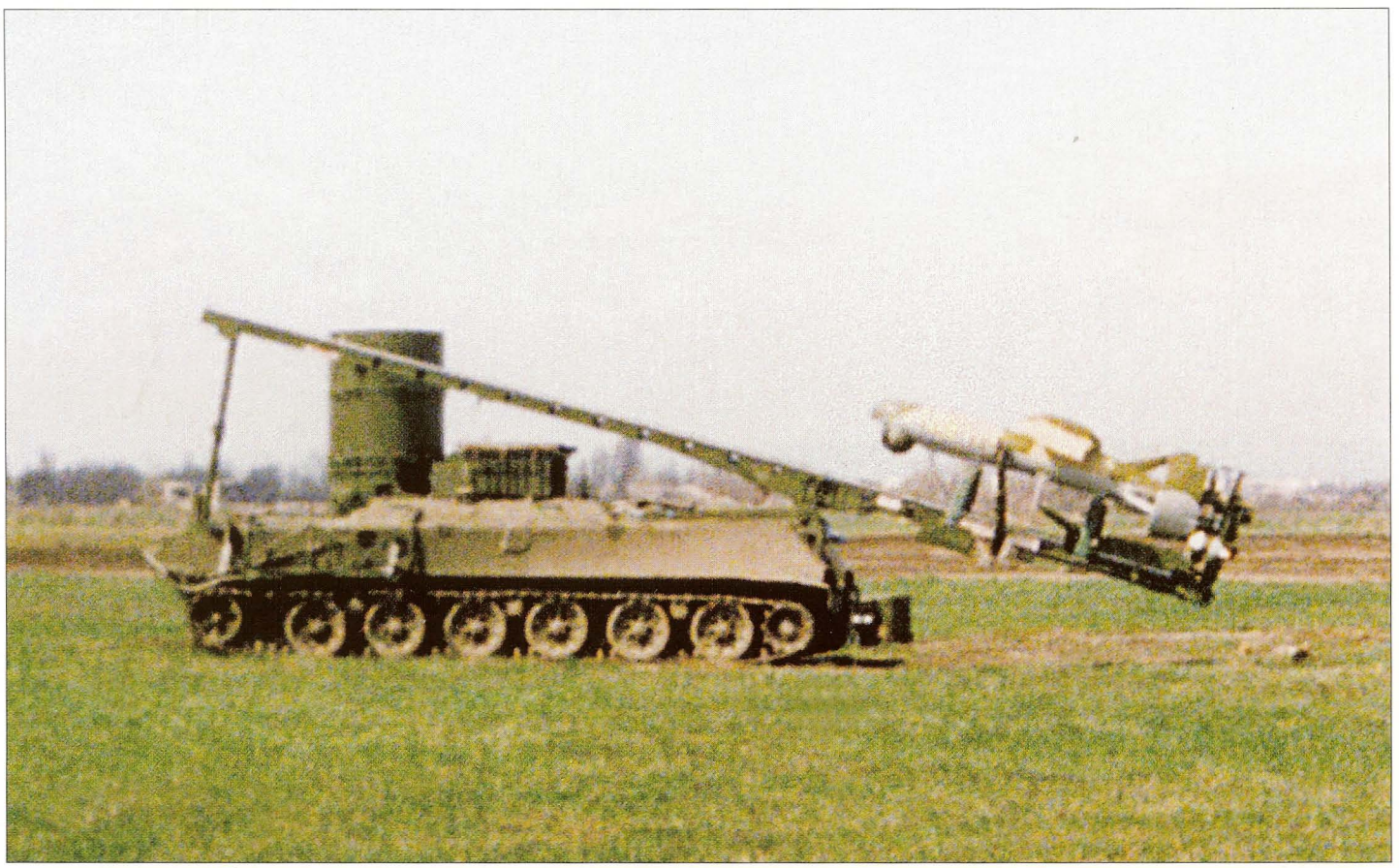
Rear view of the SPU-243 at the MAKS-97 (number plate 54-18 ZhM) in launch configuration. The rear panniers tilt together with the tube.

Above: Outwardly the Tu-243 is virtually indistinguishable from the Tu-143. The landing gear is shown here in fully extended (no-load) condition.

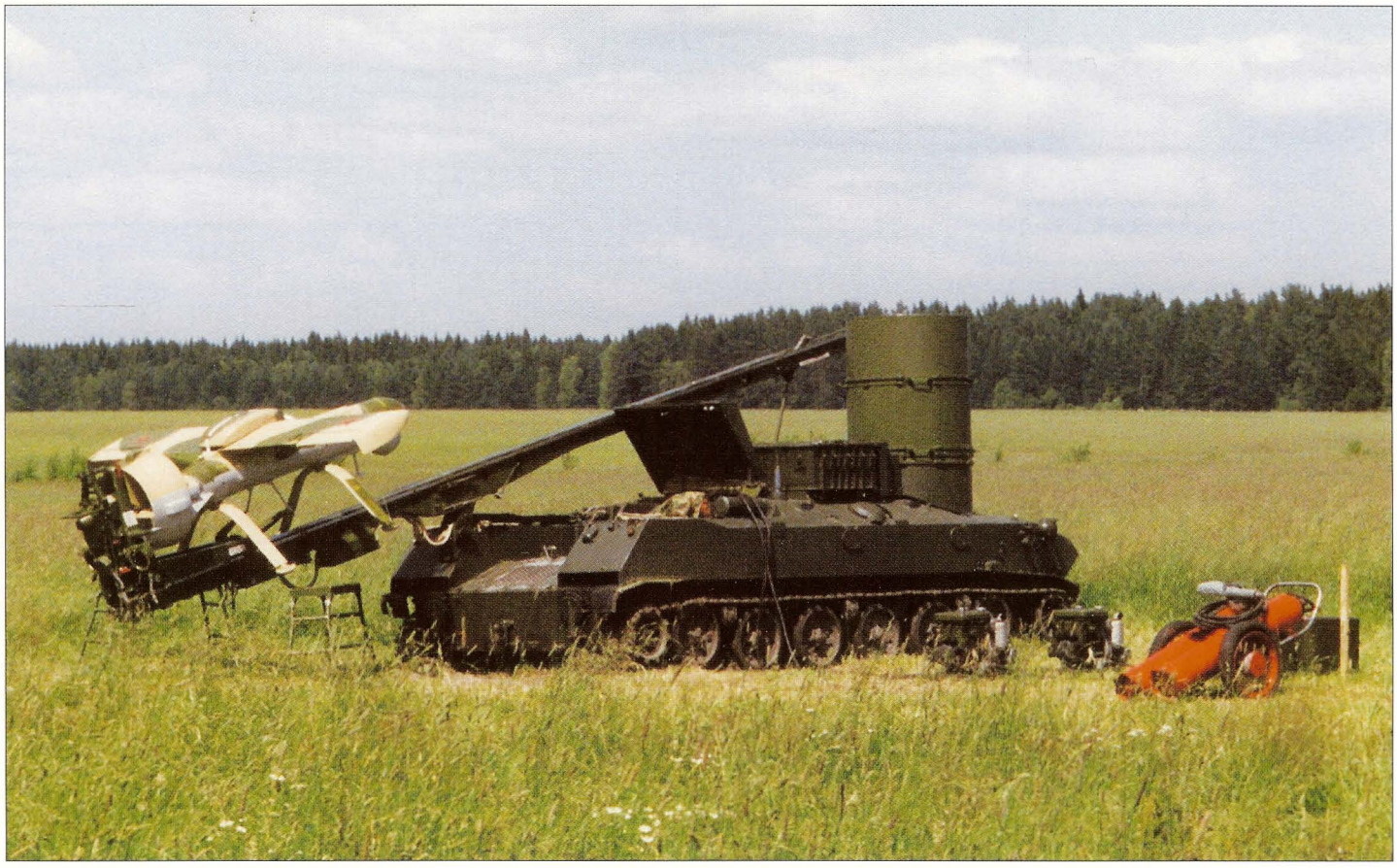
The prototype of the enigmatic Tu-300 at the MAKS-97. How long will it be before the technical details are released?...



Above: '005 Black' (c/n 005?), a prototype of the Yakovlev Shmel'-1, with the wings folded. Note the 'fishbowl' nose housing a TV camera (with an opaque top to keep the sunlight out), the lateral bulge of unknown purpose and the strange colour scheme with a camouflaged top and orange/black undersides/wing stripes.



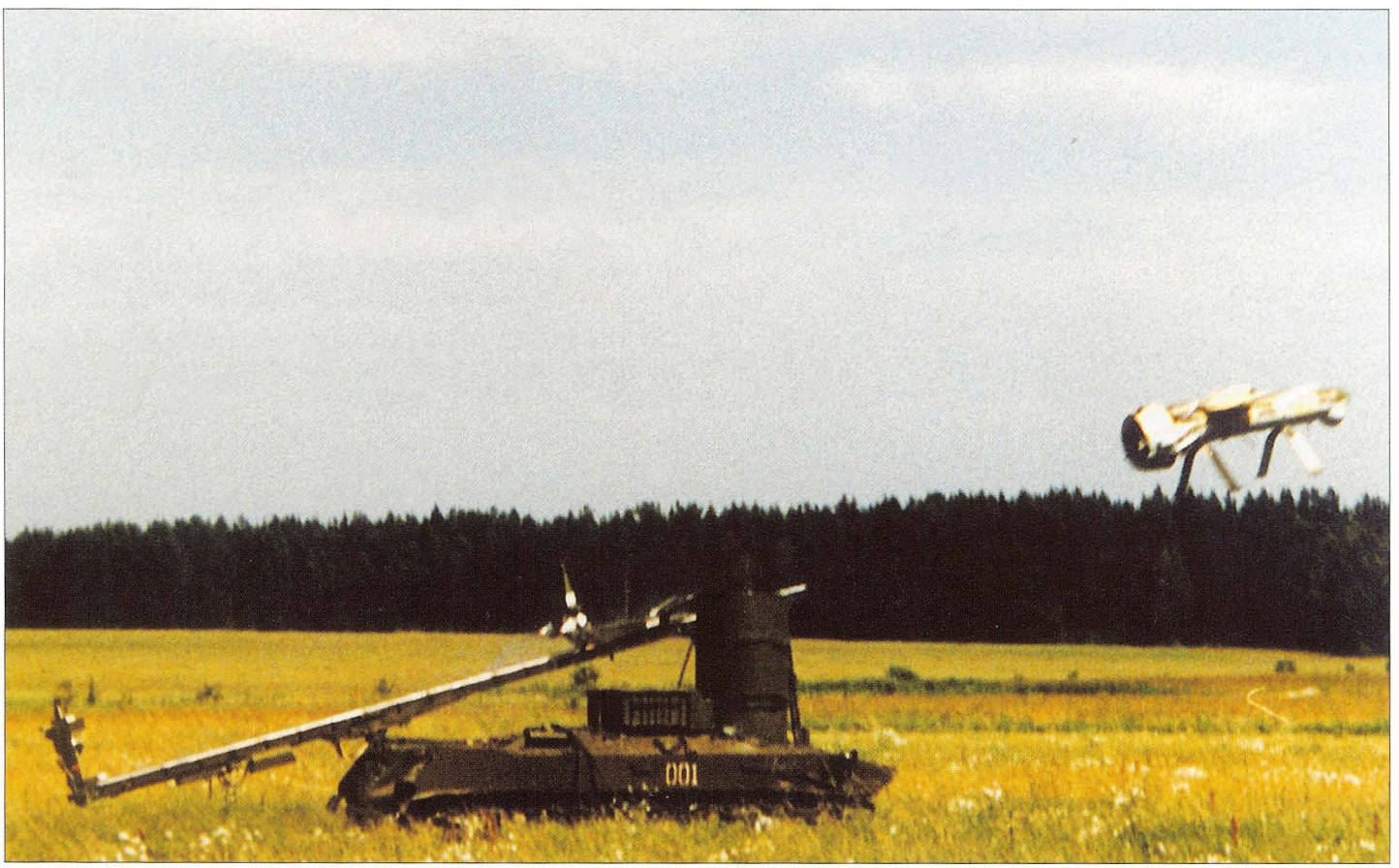
A production Russian Army Pchela-1T in a more normal camouflage scheme is about to be catapulted from its tracked launch/control vehicle.



Above: A pause in the pre-launch procedures presumably caused by the LCV's engine overheating, as indicated by the open engine compartment cover. Note the fire extinguisher cart.

The Pchela-1T is catapulted from the launch rail on a rocket-propelled sled.

Above: Another view of a Pchela-1T (*izdeliye* 61T) blasting off. The rocket booster bottles are remarkably small and have an almost spherical shape, making an interesting comparison with the cylindrical units used for the original Pchela-1 (*izdeliye* 60).

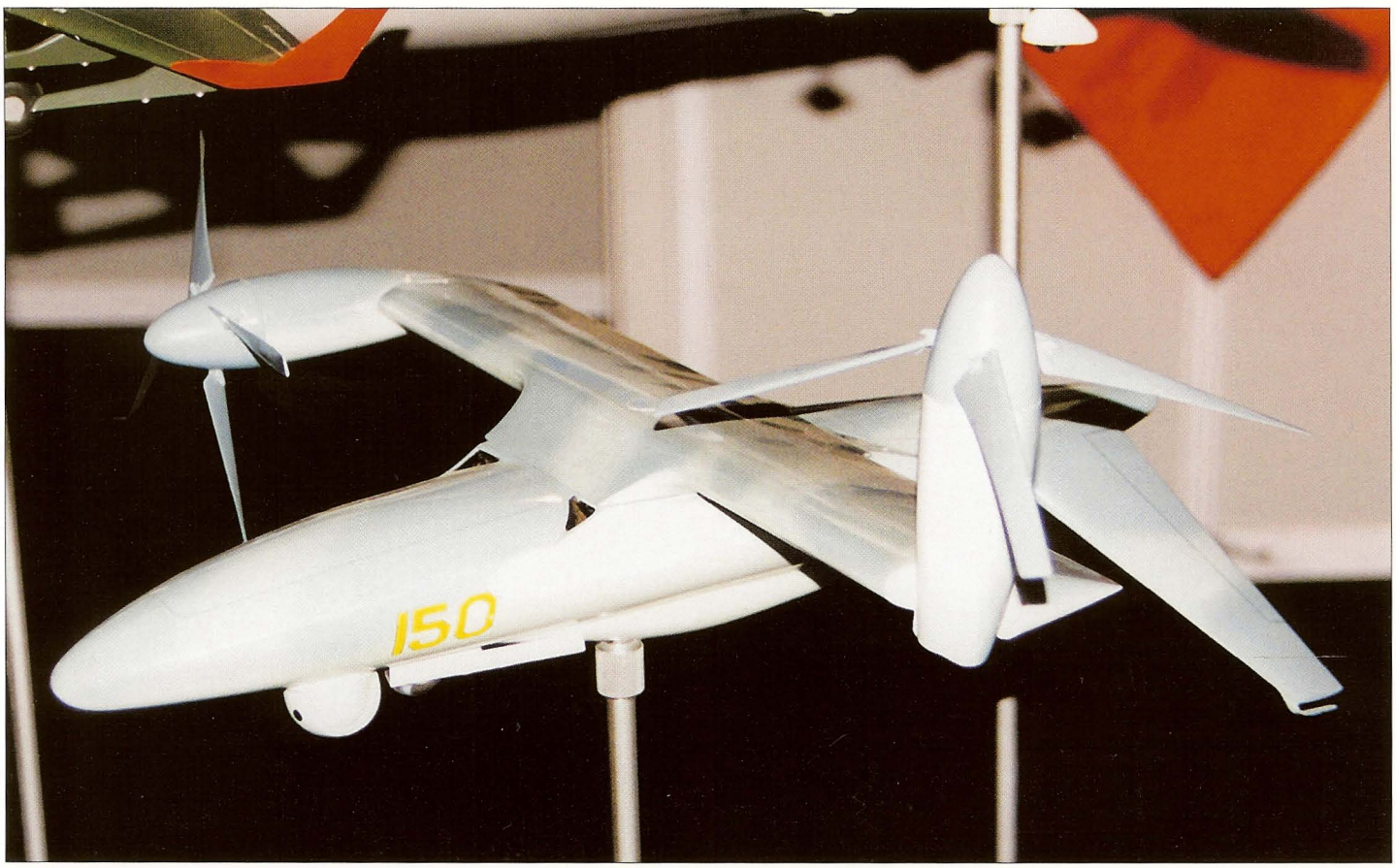


The booster charge already spent, the launcher sled rolls back as the Pchela-1T becomes airborne and climbs away.

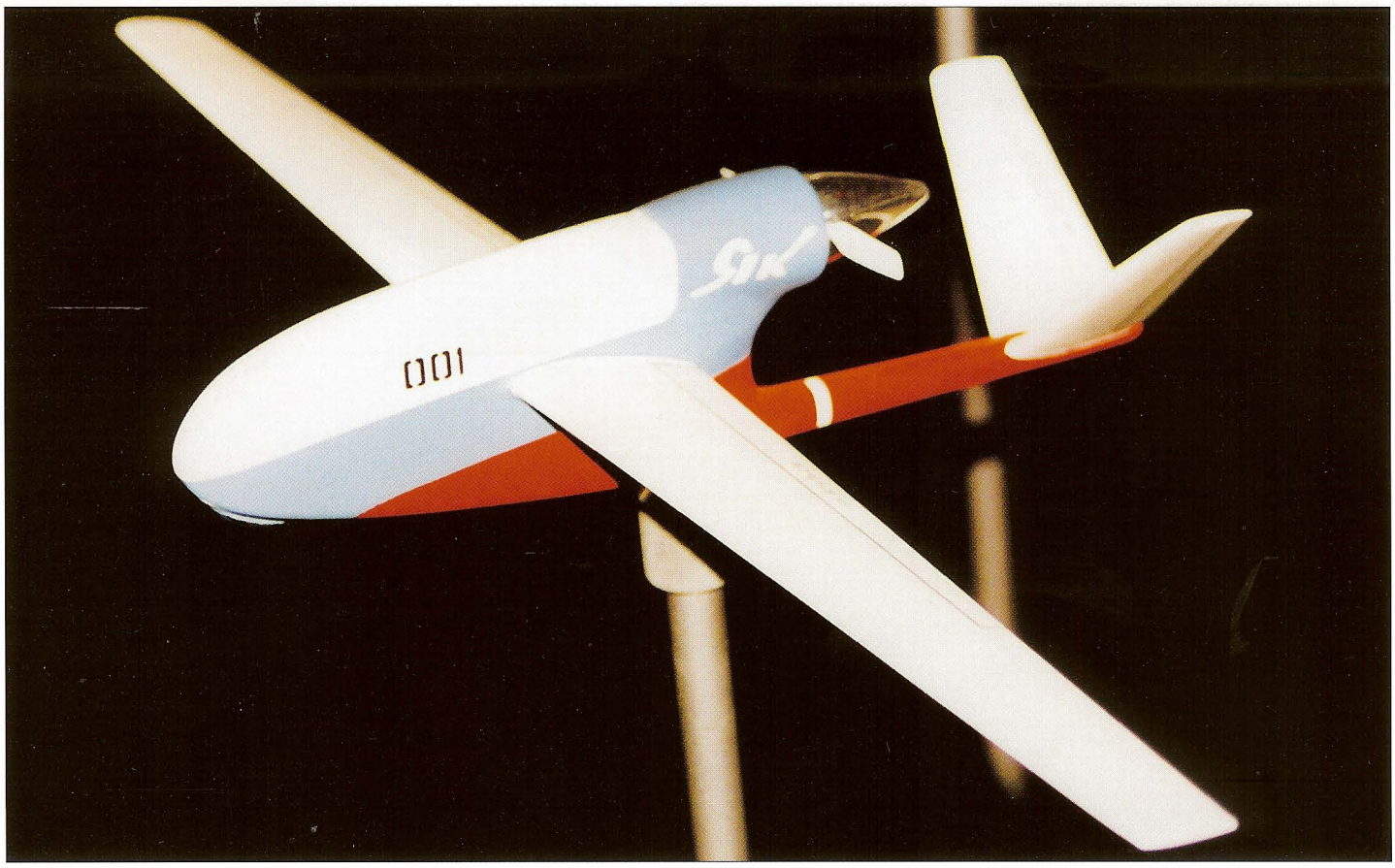
Above: The ground crew inspects the LCV with the launcher sled arrested at the top of the rail to see if everything is all right.

Pchela-1T '023 Black' (c/n 023?) in three-tone camouflage at the MAKS-99 airshow. This aircraft previously wore a smart civil-style colour scheme and Shmel' titles on the stabiliser/propeller duct. Note the ground power connectors with red 'remove before flight' covers.

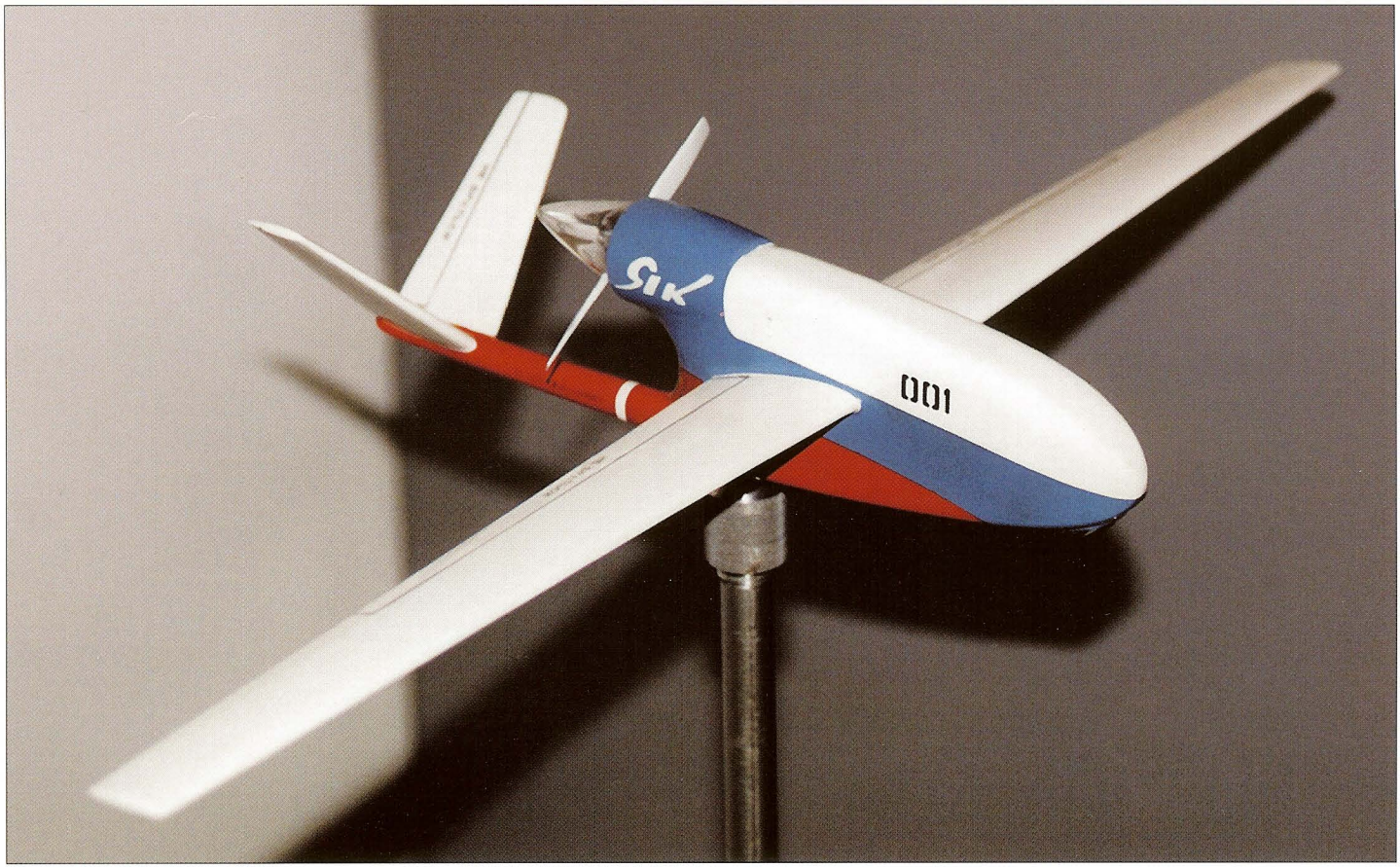
Above: A typical production Pchela-1T coded '777 Red'. Judging by what is stencilled on the wings, this machine is c/n 5950611207408, although the tail unit assembly comes from a different example (c/n 5950611207340).



A model of the Albatross VTUAV developed by the Yakovlev OKB, shown here with the monowheel retracted; note the sprung skids under the tailplane tips.



Above: A model of the Yakovlev OKB's Expert UAV designed for commercial applications. The aircraft is much smaller than one might think. The white band on the tailboom indicates the propeller rotation plane.



Another view of the Expert UAV model.

Above: Front view of a Dan' jet-powered target drone developed by the Sokol Design Bureau. This example appears to have a tracer at each wingtip.

A Dan' drone serialled '24' is lifted from a truck bed with the wings folded for storage. No engine is fitted yet.

Above: Propelled by a rocket booster, a Dan' target drone streaks away from the launch ramp which is barely visible in the smoke pall on the left.

Another product of the Sokol Design Bureau, this small target drone utilising a twin-boom layout with an inverted-V tail makes do with a pneumatic catapult mounted on an UAZ-3303 4x4 dropside 'truckster'.

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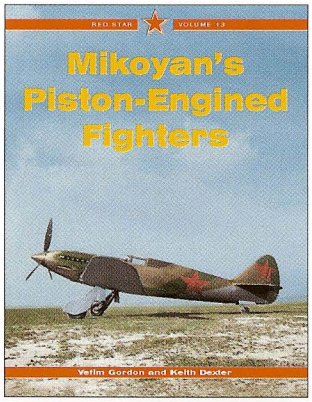
Red Star Volume 13
MIKOYAN'S PISTON-ENGINED FIGHTERS
Yefim Gordon and Keith Dexter



Describes the early history of the famous Mikoyan OKB and the aircraft that were developed. The first was the I-200 of 1940 which entered limited production in 1941 as the MiG-1 and was developed into the MiG-3 high-altitude interceptor. Experimental versions covered include the MiG-9, the I-220/225 series and I-230 series. A separate chapter deals with the I-200 (DIS or MiG-5) long-range heavy escort fighter.

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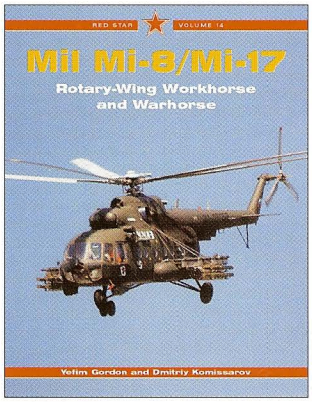
Red Star Volume 14
MIL Mi-8/Mi-17
Rotary-Wing Workhorse and Warhorse
Yefim Gordon and Dmitriy Komissarov



Since 1961, when it first took to the air, the basic design of the Mi-8 has evolved. Every known version, both civil and military, is covered, including electronic warfare, minelaying and minesweeping and SAR. It also served as a basis for the Mi-14 amphibious ASW helicopter.

Over the years the Mi-8 family have become veritable aerial workhorses, participating in countless wars of varying scale. The type is probably best known for its service in the Afghan War.

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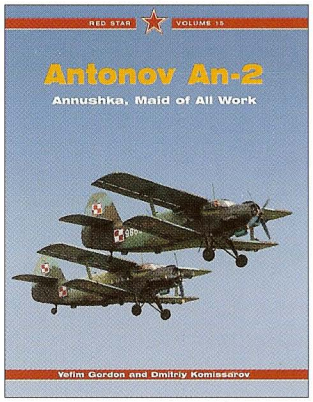
Red Star Volume 15
ANTONOV AN-2
Annushka, Maid of All Work
Yefim Gordon and Dmitriy Komissarov



Initially derided as 'obsolete at the moment of birth' due to its biplane layout, this aircraft has put the sceptics to shame. It may lack the glamour of the fast jets, but it has proved itself time and time again as an indispensable and long-serving workhorse. The An-2, which first flew in 1947, has been operated by more than 40 nations.

The An-2 is the only biplane transport which remained in service long enough to pass into the 21st century!

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The Su-9/-11/-15 and other types
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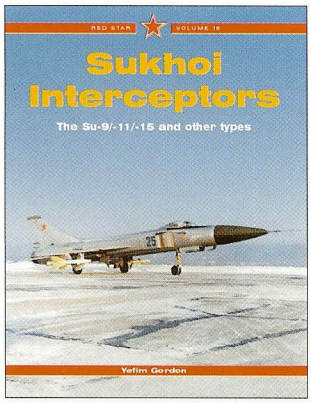

From 1953 Sukhoi produced a line of delta-winged interceptors including the Su-9 in 1958 followed in 1959 by the T-47/Su-11. A new line was started in 1960 with the twinjet T-58 which entered production as the Su-15. This aircraft remained a key element of the Soviet Air Defence Force well into the 1980s. Various versions of the Su-15 are detailed, as are the experimental PT-7/PT-8, T-49 and the unusual two-seat P-1 heavy interceptor.

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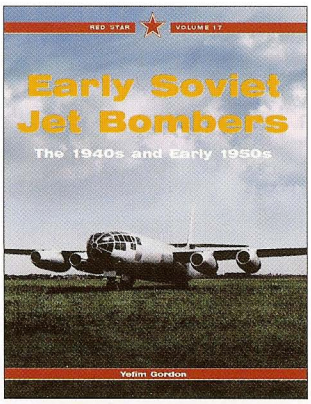

The Soviet Union put German technology to good use when developing its own jet bombers. The first to fly in the USSR was the Junkers EF131. This was followed by the EF140 and the equally unusual T-tailed, Baade 'aircraft 150'. The first wholly indigenous jet bomber was the four-engined IL-22 of 1947. Other experimental Ilyushins – the IL-30, IL-46 and IL-54 are described, as are the Tupolev 'aircraft 77', 'aircraft 82' and the 'aircraft 72/73/78' series.

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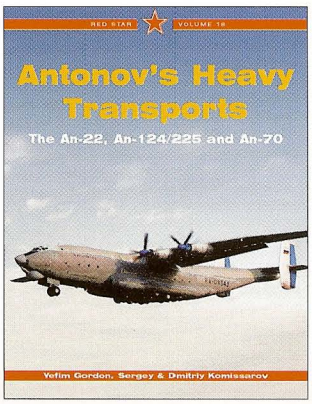

In recent times the Antonov design bureau has created a number of heavy transport types. In this volume the An-22 four turboprop aircraft is examined in detail as is the An-124, the Soviet answer to the C-5 Galaxy. Originally designed as a military freighter the An-124 has also found a niche in the civil market, as has its outsize six-engined development the An-225. The book is completed by a history and description of the propfan driven An-70 tactical transport, which is under development.

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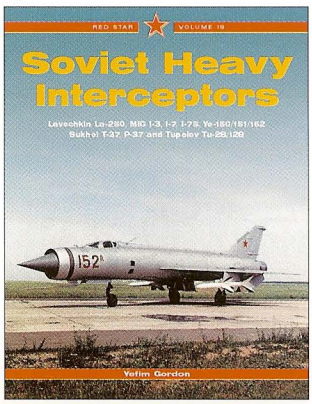

In the nervous 1950s, the Soviet Union faced the task of defending its borders against intrusions by Western spyplanes or bomber attacks. Aircraft developed for this priority long-range interception task included Mikoyan's I-3, I-7U, I-75 and Ye-152 which paved the way for the MiG-25, Sukhoi's T-37, terminated before it had a chance to fly, and Tupolev's Tu-128 – so huge it was mistaken for a medium bomber in the West.

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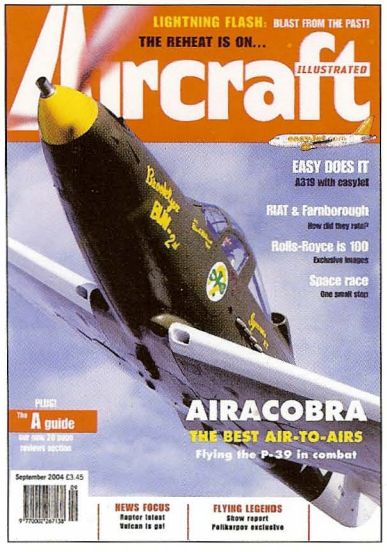

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